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ANGIOSPERM MICROFLORA OF THE EDMONTON FORMATION, ALBERTA, CANADA

by

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A THESIS

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"Pollen grains are small, so small that they cannot be seen with the naked eye; nevertheless, each is a phase in the life cycle of the flowering plant, the point in the cycle where all the potentialities and characters of the plant, be they the beauty of the rose, the majesty and dignity of the oak or the grace and elegance of the vine, are distilled into a tiny cell and cast with millions of others to the winds".

Roger P. Wodehouse, 1935.

Frontispiece: *Cranwellia bacata* n. sp. (magnification X 2,250).

ABSTRACT

142 angiosperm pollen species belonging to 52 form-genera are identified from the Edmonton Formation and formally described. Twenty natural families are represented in the microflora. Genera Aquilapollenites, Beaupreaidites, Cranwellia, Mancicorpus, Proteacidites, Scollardia and Wodehousea occur abundantly. Aquilapollenites is represented by 49 species in the Edmonton Formation.

The appearance of new microflora and termination of many elements at different horizons allows recognition of nine microfloral assemblage zones and three subzones in 840 feet of strata of the Edmonton Formation in the Red Deer River Valley, Alberta. From the bottom to the top, these assemblage zones are called the Transition Zone, the Aquilapollenites leucocephalus Zone, the Wodehousea jacutense and W. gracile Zone, the Pulcheripollenites krempii Zone, the Mancicorpus vancampoi Zone, the Scollardia trapaformis Zone, the Azolla and Balmeisporites-bearing Interval, the Wodehousea spinata Zone, and the W. fimbriata Zone. The Mancicorpus gibbus Subzone of the Scollardia trapaformis Zone may be traced in the Edmonton Formation from the Scollard region to the Cypress Hills sections situated 250 miles apart.

The regression of the Bearpaw sea allowed the onset of the continental deposition of the Edmonton Formation. Vegetation, which contributed the microflora, indicates a humid subtropical climate. The subtropical woodland flora reached its climax in the Pulcheripollenites krempii Zone underlying the Drumheller marine tongue of the Edmonton Formation. Marine waters intermingled with fresh waters during the deposition of the Drumheller marine tongue. Thus Azolla megaspores, planktonic foraminifera (Hedbergella sp.) and glauconite occur together

with the oyster beds in the Drumheller Member.

Cooling in the climate was initiated after the withdrawal of the sea which deposited the Drumheller marine tongue. Angiosperm species diminished and gymnosperm flora increased. Various temperate elements in the angiosperm microflora appeared. At the level of the lacustrine Blackmud Member of the Edmonton Formation, the climate was cool enough to support a warm temperate flora. Lacustrine conditions changed to fluvial or flood plain conditions during the deposition of the mammal-bearing member, supporting a savanna type of vegetation. By the time of the Nevis coal seam deposition, the flora had changed to warm temperate forest type.

The angiosperm microflora of the Edmonton Formation is correlated with the Maestrichtian microflora of Siberia (U.S.S.R.) and with the Hell Creek Formation of South Dakota and Montana (United States). The sediments of the Edmonton Formation from its base at East Coulee (Alberta) up to the Nevis coal seam at Scollard (Alberta) were deposited during the Maestrichtian Age.

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PROLOGUE

From his cave abodes, primitive man looked out towards the vegetation for food and fuel. The tyrannical marches of Genghis Khan, Alexander the Great, and Napoleon, to conquer the world, used, and enroute devasted, vast prairies and forests. But man still looks to the groves and meadows for physical and spiritual refuge. Verses of Omar Khayyam search for oases in the harrowing deserts, Gibran looks into blossoms for the beauty of the soul, while Milton encompasses his "Paradise Lost" in the Garden of Eden.

Retrieving the lost has always excited curiosity in man, but probing the hidden world awaited Hooke's discovery of the microscope. Now the life-cycle became clear. Nature plays the role between the maxima and minima. The gigantic oak tree is condensed into the hereditary minimum of one celled pollen, which preserves all the characters of the complicated plant, distilled into its minute genes, existing in the nucleus of the cytoplasm. Sexual fusion, metabolic changes and hormonic inductions transform this tiny pollen into the gigantic oak, made up of millions of cells patterned in elegance and grandeur. Pollen, resistant to normal decay and challenging time, have been preserved by Nature since their origin. Recovered in thousands from rock samples, these tiny cells open long vistas of many past Edens and thus is "Paradise Regained".

CHAPTER I - INTRODUCTION

During the eighteenth and nineteenth centuries, the Industrial Revolution in Europe demanded a tremendous amount of coal as its major source of energy. By the nineteenth century, various methods of correlation were employed in the exploration of coal reserves throughout the world. Plant megafossils and other remains in coal were studied for correlative evidences. Franz Schulze (1855) treated coal with a mixture of nitric acid and potassium chlorate - later widely known as Schulze Solution. Coal, macerated with this solution, yields plant remains such as cuticle, pollen and spores which are rendered clear and transparent. This discovery was the great landmark in the development of paleo-palynology.

In 1916, Lenart von Post showed conclusively that pollen and spores could be used statistically for correlation and paleoecological purposes. From this time on, palynology is generally recognised as an independent scientific discipline. During World War II, gasoline and other petroleum products were in great demand. This intensified the search for crude oil all over the world. In the late forties of this century, palynology proved to be a great help in correlating subsurface cores, obtained by drilling oil wells. Studies of spores and pollen grains were found to be of further use in correlating the marine, brackish and continental beds. During the past two decades, a large amount of palynological data has been added to the literature.

Two international conferences on palynology have been held. The 1st International Conference on Palynology was held in 1962 at Tucson, Arizona, U.S.A., and the 2nd International Conference on Palynology, at Utrecht, the Netherlands, in 1966 which commemorated the semi-centennial

of palynology.

UPPER CRETACEOUS PALYNOLOGY

The Late Cretaceous Epoch has great significance insofar as the evolution of present day flora and fauna is concerned. This time is marked by the extinction of many Mesozoic forms as well as the creation of many species, genera and families, which later evolved and dominated the Tertiary time.

During the Late Cretaceous, high mountains were arising and the development of new topography disturbed the existing climatic conditions all over the world. Rapid mutations were introduced in the existing species and the wheel of evolution was set fast. Those, fit to the new environment, survived and continued. The others died away in a short time and became extinct. Hence, in the Upper Cretaceous, many species are of short vertical distribution.

Angiosperms appeared profusely and abruptly in the Late Cretaceous. Many odd and interestingly shaped angiospermic pollen have been recorded from these beds. As yet, no definite affinity of these pollen with the modern flora has been established. These are restricted in short vertical ranges and are valuable for stratigraphic purposes. Among such pollen are Aquilapollenites, Scollardia, Cranwellia, Wodehousea, and Orbiculapollis.

In recent years much palynological work has been published on the Upper Cretaceous. Srivastava (1965) has reviewed the available literature on Upper Cretaceous palynology until 1964. Since then a considerable amount of literature has been added, which is reviewed in Appendix A following page 269.

PROBLEM AND SCOPE OF THE PROJECT

The Edmonton Formation covers most of southern Alberta, east of the foothills. It has been correlated with the Lance Formation which is Maestrichtian in age. It lies conformably over the Bearpaw Formation and underlies the Paskapoo Formation conformably at some places and unconformably at others. The Edmonton Formation is characterised by many coal seams which are irregular in thickness and distribution from place to place. Fourteen major coal seams of the Edmonton Formation have been described by Allan and Sanderson (1945). Physical correlation of coal seams has been found difficult and even unreliable due to uncertain lateral distribution and pinch out.

The Edmonton Formation has been divided into lower, middle, and upper divisions on lithologic bases. The top of the lower Edmonton is marked by the widespread marine transgression in the southern part of the formation, which is characterized by the oyster beds and is known as the Drumheller marine tongue. The top of the middle Edmonton is marked by bentonitic beds, viz. the Kneehills Tuff. These beds become untraceable in the southern part of the formation towards the Cypress Hills and the Drumheller marine tongue is untraceable in the northern part of the formation towards Edmonton.

Sternberg (1949) has noted a definite faunal break between the middle and the upper divisions of the Edmonton Formation, but no such break has been noticed between the lower and the middle divisions, in spite of the widespread marine transgression at the close of the lower Edmonton. It seems that the time lapse between the deposition of the lower and the middle Edmonton was insufficient to allow any noticeable evolutionary change in the saurian fauna. Bell (1949) noted

a floral break at the Kneehills Tuff beds i.e. between the middle and upper Edmonton divisions. No break in the flora is observed between the lower and middle divisions.

The number of coal seams, and the marine tongue, indicate that the region underwent many floodings followed by swampy conditions and transgressions of the sea several times during deposition of the Drumheller marine tongue of the Edmonton Formation. The proximity of the sea influenced the climate, which determined the vegetation of the region. Miospores deposited in contemporary times give the spectra which indicate the composition of flora of that time. Prolific development of angiosperms in the Upper Cretaceous provides the scope to use angiosperm microflora effectively for regional and inter-regional stratigraphy and correlation. The palynological evidence based on angiosperm microflora is directed toward the following goals in the present study.

1. To establish the palynologic zones in the sections of the Edmonton Formation studied.

2. To determine, for the studied part of the Edmonton Formation, the lateral distribution of key species which are significant for the stratigraphy of the area.

3. To determine which part of the upper Red Deer River section of the Edmonton Formation is represented in the studied sections of the Cypress Hills area.

4. To evaluate paleoecology of the area during the deposition of the Edmonton Formation.

5. To determine the change in flora during the deposition of the studied part of the Edmonton Formation due to climatic and/or evolutionary changes.

CHAPTER II - PREPARATION TECHNIQUE

SAMPLE COLLECTION IN THE FIELD

Vertical sections were measured and samples were collected over six inch intervals about two feet apart stratigraphically, throughout the Edmonton Formation from clayey, shaly, and coaly beds. In the case of lithologic change at closer intervals, samples were collected representing each lithologic unit. The following precautions were observed during the collection of samples.

1. Pits were dug deep enough (about 2 feet) to obtain fresh unweathered samples.

2. Samples were collected in polythene bags to avoid contamination during transportation and storage.

3. Tools were kept clean for taking every new sample to avoid contamination from the earlier sample.

4. Sample bags were tied securely and numbered corresponding to the sample number in the field book.

PROCESSING OF THE SAMPLES

Processing of samples to recover microspores involves mechanical, chemical, and gravitational (flotation) techniques. The steps followed are given below:

I. Mechanical

1. About 50 grams of a sample was taken.

2. The sample was broken to pea size by a hammer or mortar and pestle.

3. The sample was collected in a labelled polythene beaker.

II. Chemical

Note: The term "washing" has been used in the sense of "washing with distilled water" throughout the procedure technique.

4. The sample in the beaker was tested for the presence of carbonates by a drop of 10% hydrochloric acid being added.

5. If carbonates were present, the sample was treated with 10% hydrochloric acid until all the carbonates dissolved.

6. The sample was washed, at least three times, by centrifuging and decanting the water.

7. If carbonates were not present, steps (5) and (6) were omitted.

8. The sample was treated with commercial hydrofluoric acid (51% approximately) in a polythene beaker. Hydrofluoric acid was added slowly and the sample was stirred occasionally to avoid violent reaction of acid over silicates, and overflowing of the sample from the beaker. Sufficient hydrofluoric acid was added to cover the sample completely. The sample was left for about 24 hours in hydrofluoric acid and stirred frequently. If much of the silica content was still present, hydrofluoric acid was decanted from the sample and fresh acid added. The sample was again left for 12 to 20 hours with frequent stirring with a polythene rod.

9. Hydrofluoric acid was decanted and distilled water added to wash the sample by decanting it after the sample settled down. Thus the sample was washed at least three times.

10. The residue was treated with approximately 61.4% nitric acid and a pinch of potassium chlorate (about 0.5 grams) for about two hours. Occasionally a drop of the sample was checked under

the microscope to determine the desired maceration and liberation of miospores. The length of treatment was set by judging the maceration of the sample under the microscope.

11. The sample was transferred to large centrifuge bottles (100 ml) and washed by centrifuging and decanting. Short centrifuging was done to eliminate lighter organic matter other than miospores. The centrifuge machine was started and speed accelerated slowly up to 2,200 rpm and then switched off. The speed slowed by itself to 1,500 rpm and then brakes were applied to stop. This method gave satisfactory results in concentrating miospores and washing away lighter organic matter. The sample was washed until clear water was obtained after centrifuging.

Note: The same method of centrifuging was used throughout this procedure unless mentioned otherwise.

12. The residue was mixed with 10% potassium carbonate solution by shaking it well and leaving for 8 to 10 minutes.

Note: The maximum strength advised for potassium carbonate solution is 10%. It seems that the action of potassium carbonate is dependent on the degree of oxidation reached by nitric acid. If organic matter and miospores are very much oxidised, they need a short time to dissolve in potassium carbonate. If oxidation is less, miospores can stand in potassium carbonate solution for a longer period. The correct assessment of time to be given to nitric acid and potassium carbonate treatment depends largely on personal experience and needs of the worker.

13. The sample was washed until clean water appeared after centrifuging.

14. The residue was sieved through a 100 mesh (149 microns) sieve. The portion left in the sieve was collected for examining megaspores. Finer material, collected below the sieve, was centrifuged and collected in small tubes (10 ml).

III. Flotation

15. The residue was mixed with 'heavy liquid' and shaken well to disperse the material throughout the solution. The 'heavy liquid' was a mixture of cadmium iodide, potassium iodide, and zinc iodide dissolved in water, having 2.3 specific gravity. The sample was centrifuged for two minutes at a speed of about 3,000 rpm by slow acceleration.

Lighter miospores and other organic matter collected at the top of the solution, and mineral contents or other heavier matter settled at the bottom of the tube.

16. The material collected at the surface was decanted into a beaker together with the heavy liquid. The residue in the centrifuge tube was checked under microscope to determine if pollen and spores remained in it. If the residue did not contain any miospore contents, it was rejected. If miospores were left in the residue in a good quantity, it was mixed again with 'heavy liquid' and centrifuged to recover them.

17. The decanted material was diluted about five times with distilled water and left over night to settle.

18. Organic material settled down in the beaker. The upper half portion was decanted off, and the lower portion was centrifuged in small tubes (10 ml). Miospores, concentrated at the bottom of the tube, were washed several times.

Note: After centrifuging, the 'heavy liquid' may be collected, filtered and concentrated by evaporating to 2.3 specific gravity and used repeatedly.

19. A drop of the sample was checked under the microscope. If miospores needed to be clearer and organic debris was too much, a short treatment of nitric acid (5 to 10 minutes) was given, followed by washing and treatment by 10% potassium carbonate solution. After that the sample was washed again.

20. 5 cc of distilled water and a few drops of 0.5% Safrinin 0 solution were added to the residue and shaken well.

21. After about half a minute, the sample was centrifuged and washed until the water was free from stain.

22. The residue was collected in a vial labelled appropriately. A few drops of water were left in the vial, so that the sample did not dry out before making slides.

Note: Slides should be prepared before the material dries, which may take months if the vial is closed and climate is not too hot. However, for long storage, a drop of glycerine may be added to the material. Glycerine can be washed out by centrifuging the sample with water before preparing the slides.

PREPARATION OF SLIDES

1. A drop of water was put on a microscope slide.

2. A cleaned coverslip (22 x 50 mm No. 1) was placed on the drop of water. This drop of water keeps the coverslip in place on the glass slide.

3. A drop of material was placed on the coverslip.

4. About three or four drops of elvanol of moderate viscosity was put on the material and mixed well. The material was spread equally all over the coverslip. The slide was left for twelve hours at room temperature on a horizontal surface for drying. Microspores, being heavier, settle down and stick to the surface of the coverslip.

Note: (a) Elvanol is polyvinyl alcohol which hydrolyses in water. It was dissolved in warm water and filtered. The desired viscosity could be attained by adding water or evaporating it. Free flowing viscosity was preferred to avoid air bubbles. A few drops of phenol were added to prevent fungal attack.

(b) Material can be dried at low temperature on a hot plate to save time.

5. Three or four drops of thin Canada balsam was put on a clean slide and the coverslip already smeared with the material was overturned on it. Material should have been dried and free from water before mounting. Thus spores and pollen grains remain at the surface and focus clearly under high magnifications.

6. Slides were left in an oven set at 70° centrigrade for about a week.

7. Excess of Canada balsam, exuded from beneath the coverslip, was wiped off by xylene.

8. Slides were properly labelled and stored for microscopic examination.

EXAMINATION OF SLIDES

1. Slides were examined, with their labels at the right

hand side of the examiner, through the Leitz Orthomat microscope No. 594208 with attached camera.

2. Two slides were examined in all cases. In the case of samples with poor recovery of miospores, three slides were examined. The slides were examined at 1 mm interval. Very rare specimens were searched out in additional slides also.

3. All identified miospores were documented. Frequency count was done in one representative slide. More than twenty-four specimens in a sample were treated as flooding, 13 to 24 abundant, 7 to 12 as rich, 3 to 6 as common, and 1 to 2 as rare. Those species which exceeded 24 specimens in a slide were not counted further. Thus a rough estimate of relative frequency of species in each sample was determined.

DESIGNATION AND PRESERVATION OF TYPES

1. The sample numbers preceded with the code abbreviation of the locality name which are given below:

Scollard Locality 1 = Sc1-

Scollard Locality 2 = Sc2-

Scollard Locality 18 = Sc18-

Cypress Hills = CH

Morrin Bridge = MB

East Coulee = EC

Horseshoe Canyon = HC

Betty Tolman Bridge = BT

Drumheller = DH

The sample collection localities are shown in Fig. 1.

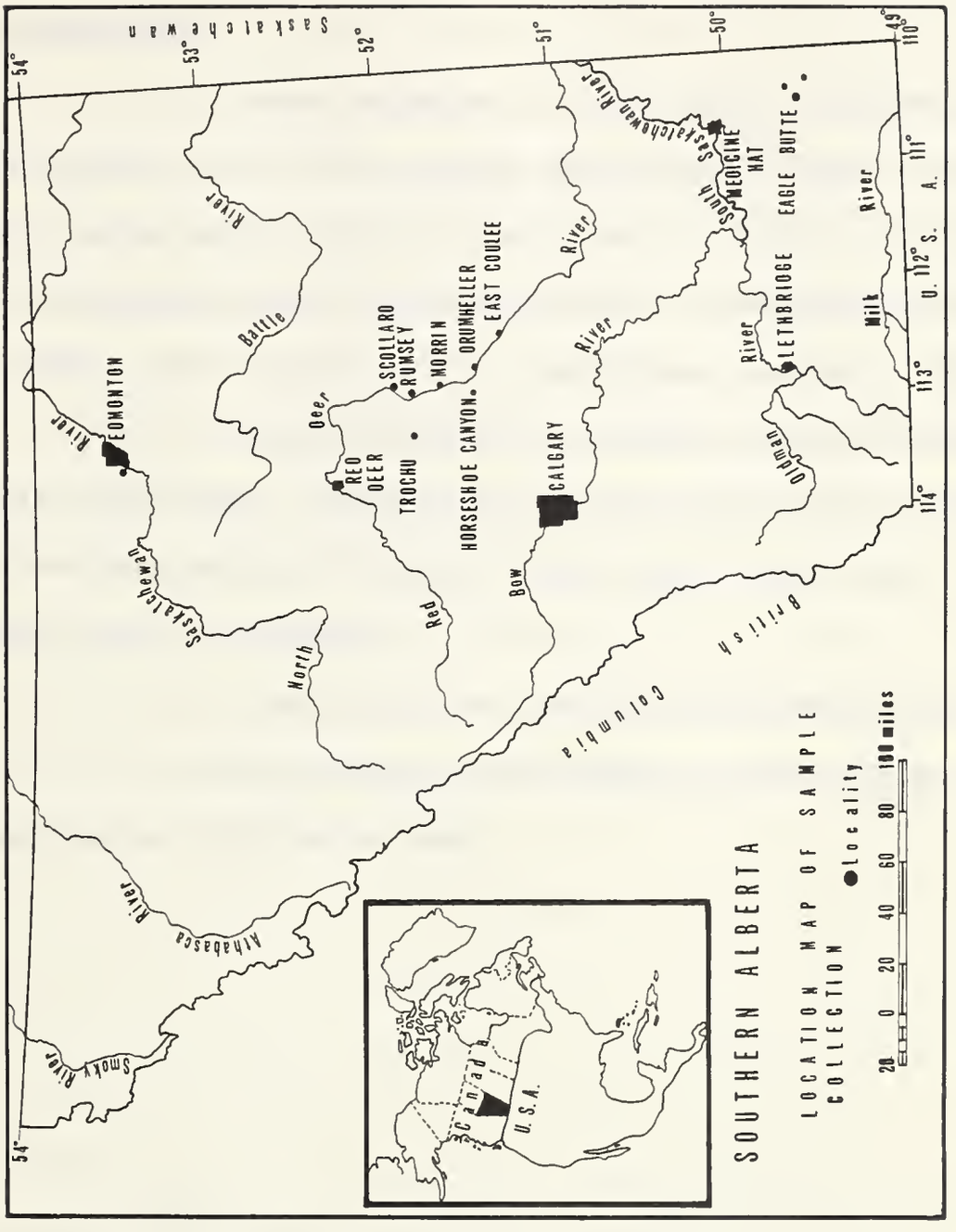

Fig. 1. Location map of sample collection, Southern Alberta.

2. All slides containing holotypes or figured specimens are deposited in the Palynology Laboratory, Department of Geology, University of Alberta, Edmonton, Alberta, Canada.

PHOTOMICROGRAPHY

1. Photomicrographs have been taken by Orthomat microscope camera on KB 14 film, mostly under objective X100 (oil immersion). Larger pollen which could not come within the field of oil immersion were photomicrographed under objective X40. Some photomicrographs were taken under objective X40 to show general pattern of whole pollen.

2. Photomicrographs were printed on Kodak Polycontrast F, single weight paper. Polycontrast filters were used for producing contrast when needed. Sometimes Kodak Bromide Grade 4 and 5, single weight paper was also used.

3. A blue filter was used for photomicrographing.

4. All specimens on the plates are illustrated at a magnification of X1,000 or X500.

CHAPTER III - STRATIGRAPHY

THE EDMONTON FORMATION

The "Edmonton" strata, named by Selwyn (1874) and designated by Tyrrell (1887) as the "Edmonton Series", were studied and given the rank of formation by Allan and Sanderson (1945). The Edmonton Formation covers much of Alberta east of the foothills and south of latitude 56°. To the east and south, it grades, in the United States, into the homotaxial Fox Hills Formation, and to the west becomes a part of the Saunders Group. The reported thickness of the Edmonton Formation is 1,000 to 1,200 feet in the plains of Alberta (Sanderson 1945), at places up to 1,700 feet (Ower 1960), and up to 2,500 feet thick in the foothills (Hargreaves et al. 1960).

The lithology of the Edmonton Formation varies both vertically and laterally. Predominantly it consists of fresh to brackish water, fine-grained sandstones, calcareous sandstones, sandy shales, bentonitic sandstones and shales, bentonite, ironstone nodules and bands, carbonaceous shales, and coal. Bentonite is conspicuously represented throughout the series of beds. The beds with shales and sandstones contain appreciable quantities of bentonite. Pure bentonitic beds are present locally. Hard, flaggy sandstones occur in the bad land topography. A tuff horizon, called the Kneehills Tuff, occurs within the Edmonton Formation in east-central Alberta, and forms a reliable stratigraphic marker over considerable distances. The Kneehills Tuff is tenatively recognised as far south as the Oldman River (Tozer 1952). Coarse clastic material is absent in the Edmonton Formation (i.e. conglomerates).

The Edmonton Formation is suggested by Allan and Sanderson

(1945) to be overlain disconformably by the Paskapoo Formation, while Campbell (1962) considered it to be conformable. Rutherford (1947), Russell (1950), Tozer (1953), Ower (1958) and Elliot (1958) expressed the view that it is conformable at some places and disconformable at other places. The marine Bearpaw Formation underlies the Edmonton Formation in southern and eastern Alberta but west and north of Edmonton and along the foothills north of Calgary, the Edmonton Formation is underlain by the Belly River Formation. The Edmonton Formation is correlated with the Blood Reserve Sandstone and the St. Mary River Formation of the southern plains, and possibly correlates in part with the lower part of the Willow Creek Formation, the Eastend, Whitemud, Battle, and Frenchman Formations of the Cypress Hills; with the Fox Hills and Lennep sandstone of Montana; and the Meeteetse and Lance Formations of Wyoming. The lower part of the Edmonton Formation is supposed to be equivalent to the upper part of the Pierre Formation of South Dakota. In the foothills, it is equivalent to the upper part of the Wapiti and Brazeau Formations.

Brown (1914) indicated that the Edmonton Formation is lithologically and faunistically an indivisible unit. He stated:

> "The Edmonton Formation consists chiefly of silicious clays interstratified with seams of lignite and thin strata of whitish sandstones. It is essentially a lignite formation".
>
> "The strata are of marine and brackish-water origin and everywhere conformably overlie the marine beds below. The whole series shows an uninterrupted successive sedimentation from purely marine conditions at the base through brackish-water during most of the period, with a gradual freshening toward the top".

Commenting on the vertebrate fauna, he added:

> "The vertebrate fauna is distinct from that of the Lance and few species are common to the two formations. Most of the

> Edmonton genera are structurally more primitive than those of the Lance and several genera not found in the Lance are common to the Judith River. The faunal facies, as a whole is intermediate, but closer to that of the Judith River formation than the Lance".

Brown (1914) noted the occurrence of the Lance genus and species Ankylosaurus magniventris, in the Edmonton Formation, but he suggested that the formation is intermediate in age between the Judith River and the Lance Formations of Wyoming, U.S.A.

After analysing the recent discoveries of fossil faunas of the nonmarine Cretaceous of the Northwestern Great plains and disturbed belt of North America, Russell (1964) suggested that the sediments from the base of the Edmonton Formation up to and including Kneehills Tuff of the Red Deer River Valley, near Drumheller, Alberta, are intermediate in age between the Judith River Formation and the Lance Formation. He calls the pre-Lance interval the Edmontonian Stage. On the basis of faunal assemblage, he suggested that the part of the Edmonton Formation above the Kneehills Tuff is equivalent to the Lance Formation which he refers to the Lancian Stage corresponding to the "Lancian Age" proposed by Dorf (1942).

Clemens and Russell (1965) noted that the tuffaceous material was deposited over the northwestern plains at the close of the Edmontonian time (sensu Russell 1964). This was followed by a period of nondeposition and local erosion. Such a local erosion has been noted in the Scollard area also (Srivastava 1965). In the Scollard Locality 1, mammal bearing beds occur about 40 to 45 feet above the Kneehills Tuff, and at a distance of about two miles, in the Scollard Locality 18, the mammal-bearing beds occur just on the Kneehills Tuff, suggesting local erosion. According to Clemens and

Russell (1965), deposition began again in Lancian time (sensu Russell 1964) after an interval of unknown duration.

SUBDIVISION OF THE EDMONTON FORMATION

Allan and Sanderson (1945) divided the Edmonton Formation into three members, viz. upper Edmonton member, middle Edmonton member, and lower Edmonton member. The subdivision was based on the presence of a widespread marine tongue (Drumheller marine tongue) at the top of the lower Edmonton member and the bentonitic tuff bed (Kneehills Tuff) at the top of the middle Edmonton member. The type areas of the Drumheller tongue and Kneehills Tuff are in the Drumheller region (Allan and Sanderson, op. cit.).

Ower (1960) divided the Edmonton Formation into five members viz. A, B, C, D, E, serially from older to younger and distinguished them mainly on lithologic grounds. Members A, B, C, and D have been correlated with the Fox Hills-Pierre Formations in age and the uppermost, E, with the Lance Formation of Wyoming. The continuous Kneehills Tuff throughout the area has been taken as a marker between Lance and pre-Lance deposition.

The status of formal member rank of the members given by Allan and Sanderson to the three convenient divisions of the Edmonton Formation is not admissible under the Article 11 (C) of the Code of Stratigraphical Nomenclature (1961). This "Article" recommends avoidance of duplication of names. Ower's (1960) nomenclature is alphabetical and hence not formal. The attitude and nature of the sequence of beds within the "members" (sensu Allan and Sanderson 1945) is such that it is suitable to call them divisions, as upper Edmonton division, middle Edmonton division and lower Edmonton division.

Lower Edmonton Division

The lower Edmonton division overlies the dark marine Bearpaw shales and underlies the middle Edmonton division. The top of the division is marked by the presence of near-shore marine strata known as the Drumheller marine tongue. The average thickness of the lower Edmonton division is about 600 feet in the Red Deer River Valley.

Four convenient members of the lower Edmonton division are proposed here:

The transition member: The transition member overlies the marine Bearpaw Formation and forms a transition from marine strata to the continental. The forty feet of the lowermost strata are thin bedded shales and fine sandstones, then 1/2 inch to 2 feet thick shaly bands alternate with 20 to 45 feet thick massive whitish sandstones. The transition member is overlain by the basal coal seam of the coaly member. The average thickness of the transition member at East Coulee (Alberta) is about 180 feet.

The coaly member: The coaly member is underlain by the transition member and its base is marked by the base of the first coal seam, up from the base of the Edmonton Formation, as exposed at East Coulee just above a massive sandstone. The top of the coaly member is marked by the coal seam below the Drumheller marine tongue which may be correlated to coal seam no. 10 (sensu Allan and Sanderson 1945). There are a number of coal seams in this member. The intervening beds between the coal seams are variable in thickness. Mostly these beds are siltstones, ironstones and bentonitic shales. The total thickness of the member is about 190 feet near the "Little Church" in the Drumheller area.

The non-coaly member: The non-coaly member overlies the top coal seam of the coaly member and underlies the lowermost oyster horizon of the Drumheller marine tongue. This member is mainly composed of massive sandstone intercalated with thin beds of sandstones, shales, ironstones and bentonitic shales. The approximate total thickness of this member near the "Little Church" in Drumheller is about 80 feet. Near the "Little Church" in the Drumheller area, the top of this member lies at about 60 feet below the local oyster bed near the prairie level.

The Drumheller Member: The Drumheller marine tongue overlies the non-coaly member of the lower Edmonton division and underlies the Tolman Member of the middle Edmonton division. The base of the member is marked by the lowest oyster bed, but north of the "Little Church", it is placed at the base of a massive sandstone (32 feet thick) about 60 feet below the oyster beds in that area. The top of the section there is marked by lensing oyster beds. Where both upper and lower oyster beds are present (as at Morrin Crossing) the thickness of this member is 70 to 100 feet. The marine tongue is characterised by the presence of oyster beds and bluish siltstones. Near Scollard the oyster bed facies changes and the lower part of the tongue may have become a fresh water facies. The upper part of the marine tongue can still be traced through the Scollard region by the presence of shark teeth (Stelck, C. R., pers. comm.).

Middle Edmonton Division

The contact between the lower and middle Edmonton divisions has been placed at the top of the Drumheller marine tongue, above beds

containing Corbicula occidentalis ventricosa. The uppermost bed at the top of the middle division is a dark grey to mauve-black shale (Battle) enclosing selenite crystals. These dark beds have been referred by Srivastava (1965) as "Blackmud" (= mauve shale sensu Snead 1968). These include the thin silicified tuff layers known as the Kneehills Tuff. The Blackmud beds are underlain by prominent, white bentonitic shaly sandstones, referred to by Srivastava (1965) as "Whitemud" beds (= Whitemud Formation of Cypress Hills).

One coal seam occurs about 50 feet below the tuff horizon. The intervening beds are interlensing bentonitic sandstones and siltstones of drab color. Below this coal seam is another at an interval of 50 to 100 feet. Rocks below this seam have slightly less admixture of calcareous and ferruginous matter. The middle division is approximately 300 feet thick.

The middle Edmonton division is here subdivided into four members viz. Tolman, coaly, Whitemud and Blackmud Members.

The Tolman Member: The strata overlying the uppermost oyster bed of the Drumheller marine tongue of the lower Edmonton division and underlying the basal coal seam of the coaly member of the middle Edmonton division comprise the Tolman Member designated here. The Tolman Member consists of sandstones and siltstones with some admixture of calcareous and ferruginous matter. The average thickness of this member near Tolman bridge in the Red Deer River Valley is about 130 feet. For formal designation see Appendix B on page 295.

The coaly member: The coaly member overlies the Tolman Member and underlies the Whitemud Member of the middle Edmonton division. The base of this member is marked by the base of a coal seam about 100 to 150 feet below the Kneehills Tuff. This coal seam is exposed at the

top of the Betty Tolman section near Tolman Ferry and may be equivalent to the Carbon coal seam no. 11 (sensu Allan and Sanderson 1945). The top of this member is marked by the top of another coal seam which may be equivalent to the Thompson coal seam no. 12 (sensu Allan and Sanderson 1945) which is about 50 feet below the Kneehills Tuff. The intervening beds are interlensing bentonitic sandstones and siltstones of drab color. The total thickness of this member varies from 50 to 100 feet.

The Whitemud Member: This member overlies the top of the coal seam of the coaly member of the middle Edmonton division which is about 50 feet below the Kneehills Tuff and underlies the Blackmud Member. The Whitemud Member contains prominent, white, bentonitic shaly sandstones. These beds have been referred by Srivastava (1965) to "Whitemud" beds equal to Whitemud Formation of the Cypress Hills. This member is 18 to 20 feet thick in the Red Deer River Valley in the Scollard area, however, if coaly streaks have been introduced into the Whitemud interval in the Scollard area, the Whitemud Member may be equivalent only to the upper portion of the Whitemud Formation of the Cypress Hills (Furnival 1946, p. 78).

The Blackmud Member: This member overlies the white bentonitic, shaly sandstone beds which are called here Whitemud Member and underlies the mammal-bearing member of the upper Edmonton division. The Blackmud Member (= mauve shale sensu Snead 1968) comprises dark grey to mauve-black shales enclosing selenite crystals. These include a silicified tuff layer called the Kneehills Tuff. Such tuff layers occur in the Battle Formation also. The thickness of the Blackmud Member in the Scollard area of the Red Deer River Valley varies from 18 to 25 feet.

The Blackmud Member has been correlated with the Battle Formation in the Cypress Hills and the silicified bentonitic tuff also occurs in both strata. Binda and Srivastava (1968) recovered many well preserved silicified megaspores from both the Blackmud Member and the Battle Formation. Several silicified megaspore species are common to both strata, suggesting contemporaneity of the Blackmud Member and the Battle Formation.

The Kneehills Tuff: The volcanic ash bed in the Edmonton Formation on the Red Deer River east of the town of Ardley, has been recognised as the Kneehills Tuff by Sanderson (1931). To the south and east, it has been detected on the north flank of Wintering Hills and on the south slope of Hand Hills. The maximum thickness of the bed is seldom more than eight inches. The silicified band of tuff occurs at different levels within the Blackmud Member and from place to place different silicified bands may become locally known as the Kneehills Tuff (Allan and Sanderson 1945; Ritchie 1960). Such an occurrence has been noted in Scollard Localities 1 and 18 (Srivastava 1965).

The Kneehills Tuff is a light tan-grey in color, weathering lighter. It is hard, massive and very fine grained. Usually, it is structureless, sometimes showing vague bedding features. It forms a talus by breaking into sharp angular fragments. Vugs filled with opaline silica or bentonite clay are visible. The tuff is made up of fresh angular quartz and feldspar fragments from 0.03 to 0.05 mm in diameter, set in an isotropic ground mass. Typically curved volcanic glass shards are present but not common. The ground mass material contains mainly opaline silica and montmorillonite. Silica content

of the tuff is usually over 90% (fide Ritchie 1960).

The individual tuff fragments have been interpreted to be wind-carried material originating from separate explosive outbursts at the source. This ash was deposited in freshwater basins and altered diagenetically. The Kneehills Tuff is correlated with a source in the igneous rock to the south west in Montana (Sanderson 1945; Ritchie 1960).

The radiogenic age of the Kneehills Tuff is given as 70 million years by Ritchie (1960), and 66 million years by Folinsbee et al. (1961) and Shafiqullah (1963).

Upper Edmonton Division

Sanderson (1945) included within the upper division those beds above the Ardley coal seam up to an erosional unconformity at the base of the Paskapoo Formation, as well as the coal seams and beds down to the top of a dark shale which includes the volcanic ash bed - the Kneehills Tuff. Except for two to four beds of coal lying below the Ardley seam, the upper Edmonton is composed of light colored sandstone and siltstone, with local lenses of more argillaceous and ferruginous beds. The thickness of the upper Edmonton division ranges from 200 to 290 feet in the Red Deer River area.

Ower (1960) studied surface samples and well logs of the Edmonton Formation of central Alberta. He found no evidence of irregular differential erosion of the Edmonton Formation before the deposition of the Paskapoo Formation. According to him, if a disconformity exists between the Paskapoo and the Edmonton Formation, it may be at the base of the massive sandstone above the Ardley seam at Ardley and above the Pembina seam in the North Saskatchewan and Pembina Rivers. Thus the

thickness of member E or the upper Edmonton division would be reduced to 184 feet in the Ardley surface section. Earlier Tyrrell (1887) had also drawn the upper limits of the Edmonton Formation at the top of the Ardley coal seam. Sternberg (1949) located dinosaurian remains at several horizons up to 90 feet above the top of the Ardley seam which seems to justify the inclusion of the beds above the Ardley seam up to the erosional unconformity at the base of the Paskapoo Formation in the Edmonton Formation.

Elliott (1960) recognised certain coarse sandstones at the base of the Paskapoo Formation. According to him this supported the suggestion of a disconformity between the base of the Paskapoo and the underlying Edmonton Formation.

Mammalian fossils have been reported from the Upper Edmonton division. The fossiliferous beds containing the mammalian remains occur about 45 feet above the Kneehills Tuff (Clemens and Russell 1965). Srivastava (1965) mentioned the occurrence of mammalian fossils in Scollard Locality 1, 45 feet above, and in the Locality 18, immediately above the Kneehills Tuff. A minor erosional unconformity might be inferred to be below the Scollard mammal-beds in the Upper Edmonton division.

The sandstones of this division are characterised by greyish white to yellowish grey color, poor sorting, prevalence of feldspar, some plagioclase, with garnet, apatite and zircon. The detrital grains of the upper Edmonton division are derived mainly from a sedimentary source and some contribution has been made by metamorphic and acid igneous rocks (Chi 1966).

The upper Edmonton division of the Red Deer River Valley

is divided into two members: a lower mammal-bearing member and an upper coaly member (Nevis Member).

The mammal-bearing member: This member is underlain by the Blackmud Member containing the Kneehills Tuff and is overlain by the Nevis coal seam of the Nevis Member. The mammal-bearing member consists of sandstones intercalated with shaly beds and coaly streaks. Mammal and dinosaur bones have been located in this member at several horizons as reported by Clemens and Russell (1965). The total thickness of the mammal-bearing member is about 140 to 150 feet in the Red Deer River Valley of the Scollard area.

The Nevis Member: The Upper coaly part of the upper Edmonton division i.e. from the first coal seam above the Kneehills Tuff (Nevis coal seam sensu Allan and Sanderson 1945) to the base of the Paskapoo Formation is included in the Nevis Member designated here. The maximum thickness of the member is about 140 feet in the Scollard area. For formal description of the Nevis Member see Appendix B at page 296.

The stratigraphic relation of various members proposed here with those of the Edmonton Formation proposed by Allan and Sanderson (1945) and Ower (1960) is shown in Fig. 2.

PALEONTOLOGY OF THE EDMONTON FORMATION

Invertebrate fossils: About 50 to 60 species are recorded from the Edmonton Formation but they are not too diagnostic stratigraphically. Fresh water and terrestrial invertebrates are poorly preserved and difficult to collect. The marine fauna is numerically small as compared to that of formations like the Fox Hills and is correlative with the Upper Cretaceous faunas in eastern Montana and the Dakotas. The disparity in the marine fauna of the Edmonton Formation and the

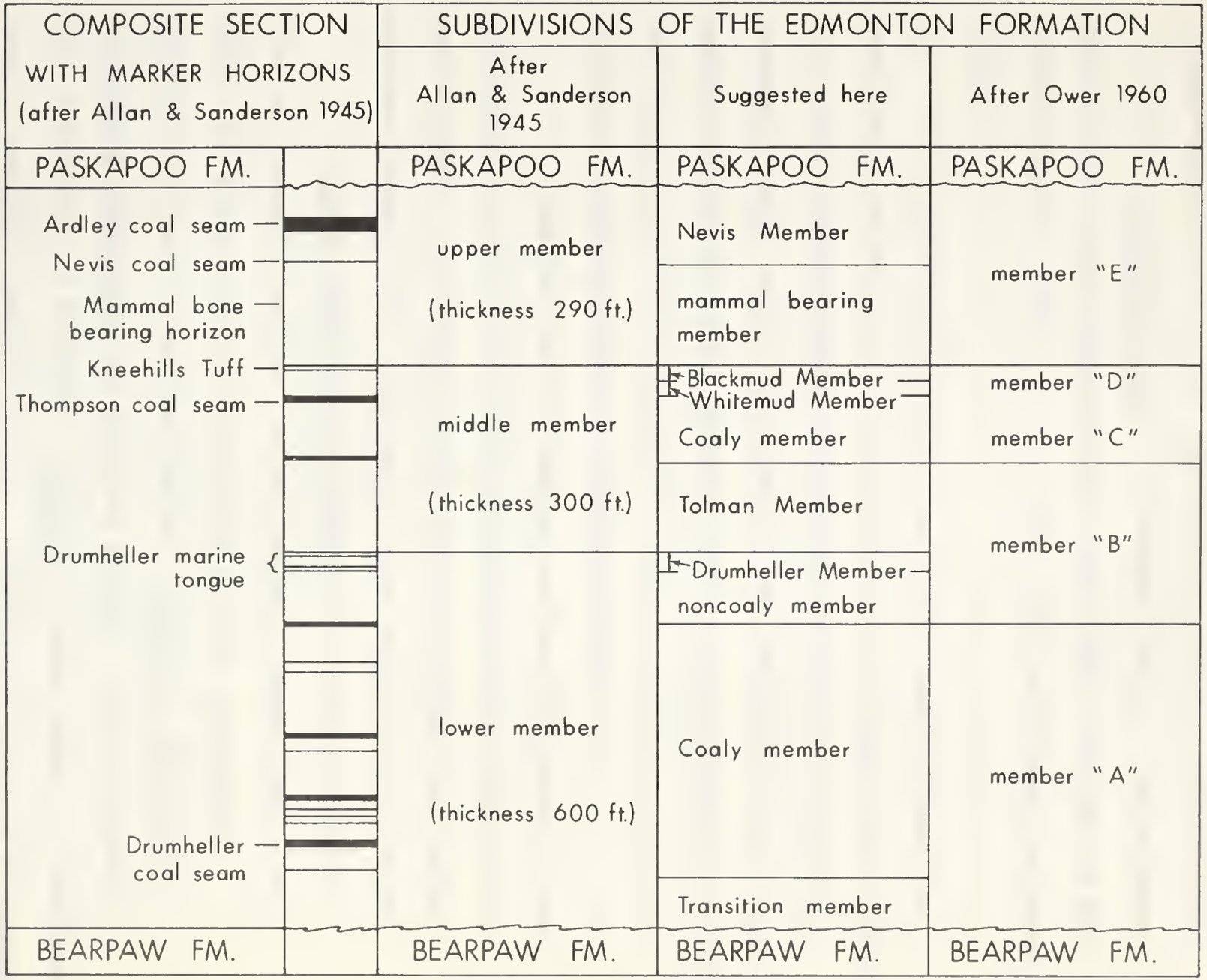

Fig. 2 Stratigraphic relation of members of the Edmonton Formation herein proposed and those proposed by Allan and Sanderson (1945) and Ower (1960).

Fox Hills may be due to the transient incursion of the sea during the deposition of the Edmonton Formation - too brief to permit immigration of representatives of all the forms found in Montana (Sanderson 1945).

Vertebrate fossils: Vertebrate fossils from the Edmonton Formation have been reported upon by Brown (1914), Williams and Dyer (1930), Sternberg (1940a, b, 1945, 1947, 1949), and Clemens and Russell (1965).

A definite dinosaurian faunal break occurs between the middle and upper Edmonton but such a break has not been noticed between the lower and middle Edmonton divisions in spite of the widespread Drumheller marine tongue. It seems that the Drumheller tongue transgression was extensive over the area studied, but its duration was short, and no great evolutionary change took place from before to after the Drumheller tongue was laid down (Sternberg 1949).

Mammalian fossil localities have been discovered in the upper Edmonton about 45 feet above the Kneehills Tuff (Clemens and Russell 1965). The Scollard mammal quarry has yielded over twenty species of mammals (J. A. Lillegraven, pers. comm. to C. R. Stelck).

Flora of the Edmonton Formation: Plant megafossils from the Edmonton Formation remain limited in number (Bell 1949, 1965). The fossil flora is represented by ferns, cycadophytes, ginkgophytes, conifers and dicotyledons. Sequoites, Elatocladus intermedius, Dombeyopsis and Vitis are abundant below the Kneehills Tuff in the Edmonton Formation. Platanus is common among the dicotyledonous trees in the upper Edmonton division. Fossil woods belonging to Taxodium, Sequoia, Glyptostrobus and Cephalotaxus have been found in abundance in the lower Edmonton division near the "Little Church" at Drumheller

(C. G. K. Ramanujam, pers. comm.).

On the basis of the flora recorded from the Edmonton Formation, Bell (1949) divided it into two assemblages, one recovered above the Kneehills Tuff beds in the upper Edmonton, and the other below the Kneehills Tuff beds in the rest of the formation. The assemblage of the flora, recorded below the Kneehills Tuff, is characteristic of the formations which are approximately of similar age as that of the Fox Hills and the lower part of the Medicine Bow in the United States.

Filicites knowltoni, Carpolithus ceratops, Annona robusta and Fraxinus leii are the diagnostic species of the upper Edmonton flora and also characteristic of the Lance Formation. Carpolithus ceratops and Fraxinus leii occur also in the Frenchman Formation.

Srivastava (1965, 1966, 1967, 1968) studied the microflora of the Blackmud and the mammal-bearing member of the upper Edmonton division. He recovered a rich microspore assemblage and recognised five microfloral zones (1965, 1967), which are discussed in this study as zone VIa, upper VI, VII, lower and upper VIII (Fig. 19).

CORRELATION AND AGE OF THE EDMONTON FORMATION

On the basis of the plant fossils, dinosaurian and mammalian fauna, Bell (1949), Sternberg (1949) and Clemens and Russell (1965) arrived at the conclusion that the Upper Edmonton is correlative to the Lance Formation of Wyoming.

Species of silicified megaspores have been recovered from both the Blackmud Member of the middle Edmonton division and the Battle Formation of the Cypress Hills (Binda and Srivastava 1968). Thus the

Blackmud Member (= mauve shale sensu Snead 1968) is correlative to the Battle Formation. Ritchie (1960) has also correlated the "Dark Zone" (= Blackmud Member of the middle Edmonton division) with the Battle and the "White Zone" (= Whitemud Member of the middle Edmonton division) with the Whitemud Formation of the Cypress Hills.

The microflora recovered from the Blackmud Member (mauve shale sensu Snead 1968) of the Edmonton Formation has shown a close resemblance with the microflora of zone I and II of the Crow Butte section of the Hell Creek Formation, north western South Dakota (Srivastava 1965, 1966, 1967; Stanley 1965). The microflora of the lower part of the upper Edmonton division also contains Aquilapollenites conatus reported by Norton (1965) from the Hell Creek Formation of Garfield County, Montana.

Bell (1949) correlated the various formations of the southern Alberta Plains with those of eastern Montana, U.S.A. (Fig. 3). He suggested that the Edmonton Formation belongs to Maestrichtian-Danian Age. Woodward et al. (1959) also correlated the Edmonton Formation with other formations in the area but assigned a Campanian-Maestrichtian Age. All the evidence accumulated tend to show that the sediments above the Kneehills Tuff are equivalent to the Lance Formation in time and Late Maestrichtian in age. The radiogenic age of the Kneehills Tuff and Ardley coal seam is 66 million years and 63 million years respectively (Folinsbee et al. 1961; Shafiqullah 1963).

PALEOECOLOGY OF THE EDMONTON FORMATION

The lithology of the strata and the distribution of many coal seams in the Edmonton Formation suggest their deposition under

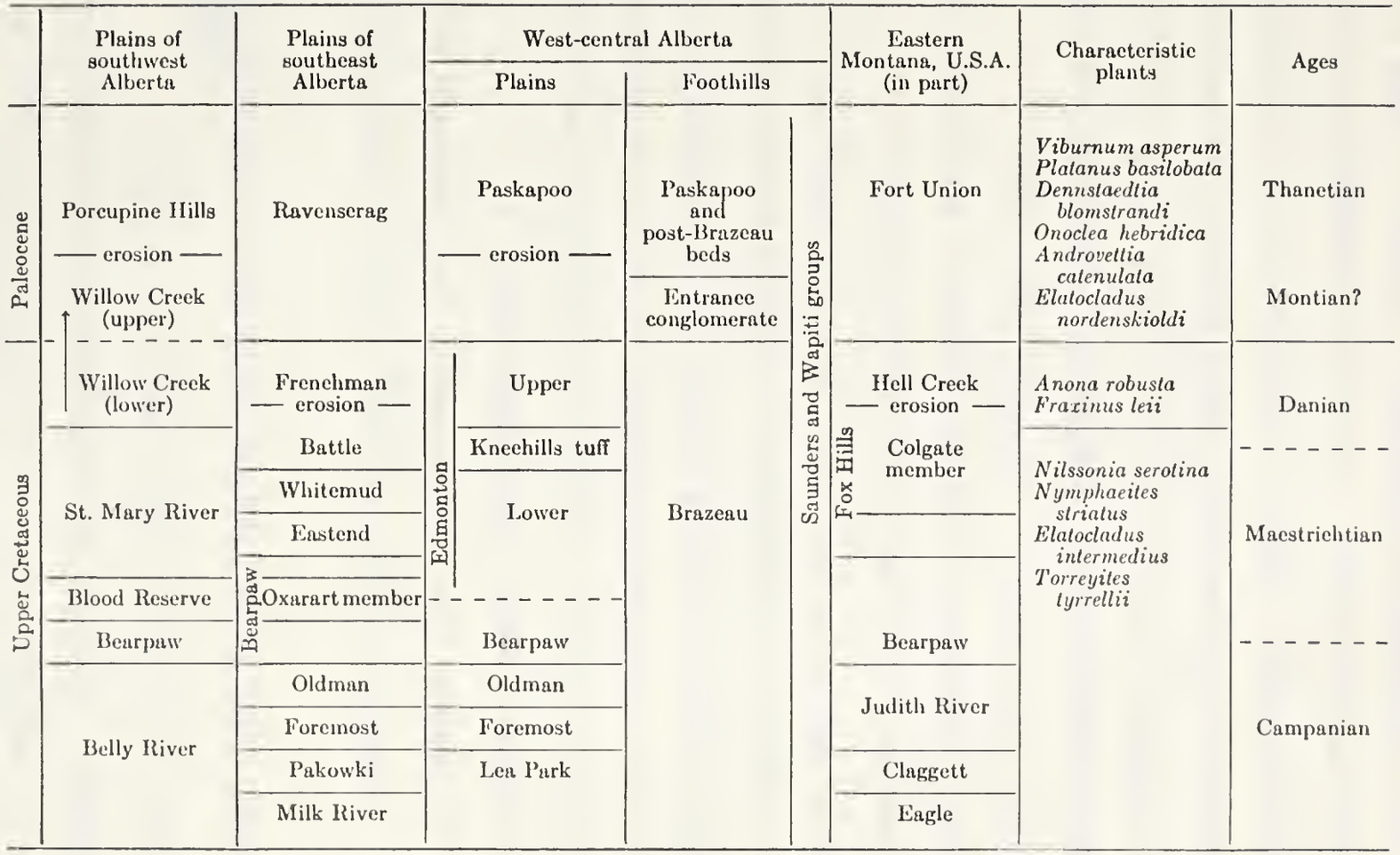

Figure 3: Stratigraphic correlation of the Edmonton Formation with the Formations of southern Alberta Plains and eastern Montana, U.S.A. (after W.A. Bell, 1949).

fresh and brackish water conditions. Sediments were deposited in shallow fresh-water basins, or in estuaries and deltas, or in littoral zones along the border of advancing or retreating seas. Some of the beds were deposited as mud flats. Beds containing carbonaceous matter originated in enclosed basins or swamps. Allan and Sanderson (1945) enumerated many characteristics which show the continental mode of deposition of the Edmonton Formation and they suggested that these beds were deposited in a long and relatively broad composite delta.

Bell (1949) suggested a coastal plain environment which may be the cause of widely scattered distribution of water plants.

Srivastava (1965, 1967) suggested a subtropical climate during the deposition of the first coal seam below the Kneehills Tuff in the Scollard Locality I. The microflora indicates a cooler climate (warm temperate) in the Scollard area at the level of Triceratops bones in the upper division of the Edmonton Formation. The distribution of water plants throughout the deposits indicates marshy conditions.

D. A. Russell and Chamney (1967) attempted to show the marine transgressions and regressions with reference to the distribution of microfossils recovered from the Edmonton Formation.

Upper Cretaceous stratigraphy in the Cypress Hills area in southeastern Alberta

Russell and Landes (1940) and Furnival (1946) have described the geology of the Cypress Hills area in detail. Campbell (1962) attempted to correlate the various Upper Cretaceous formations of the Cypress Hills area with the various members of the Edmonton Formation as proposed by Allan and Sanderson (1945) and Ower (1960). Such a

correlation proposed by Campbell (1962) is shown in Fig. 4.

A brief introduction to the Upper Cretaceous stratigraphy of the Cypress Hills area in southeastern Alberta is given below:

Bearpaw Formation: The Bearpaw is of marine origin, consisting predominantly of dark grey or brownish grey shale tending to weather into small angular fragments or flakes. Spheroidal ironstone concretions are common in irregular zones, and often contain fossils. Bentonite beds, usually a fraction of a foot in thickness, persist remarkably in lateral extension (Russell and Landes 1940). The Bearpaw is conformably overlain by the Eastend Formation (Hargreaves et al. 1960). Campbell (1962) correlated the top of the Bearpaw Formation in the Cypress Hills with the top of the lower Edmonton, which may suggest that the Drumheller marine tongue is the last expression of the Bearpaw sea transgression.

Eastend Formation: In Alberta, the Eastend Formation in the Cypress Hills area is overlain by the Whitemud Formation and underlain by the marine Bearpaw Formation. At the type locality, it is about 70 feet thick. The Eastend Formation is essentially a sandy, silty sequence and records conditions transitional from the marine Bearpaw to the nonmarine Whitemud Formation. Its development in Alberta is far less uniform than in Saskatchewan and consists of massive, medium-grained sandstones, dark shales and carbonaceous beds. The Eastend Formation of southeastern Alberta corresponds with the upper part of the Edmonton Formation according to Russell and Landes (1940), whereas Campbell (1962) has correlated it with the lower part of the middle Edmonton.

Whitemud Formation: The distribution of the Whitemud Formation is very dicontinuous. It is well exposed in the north eastern part of the Cypress Hills, where it overlies the sandstone of the

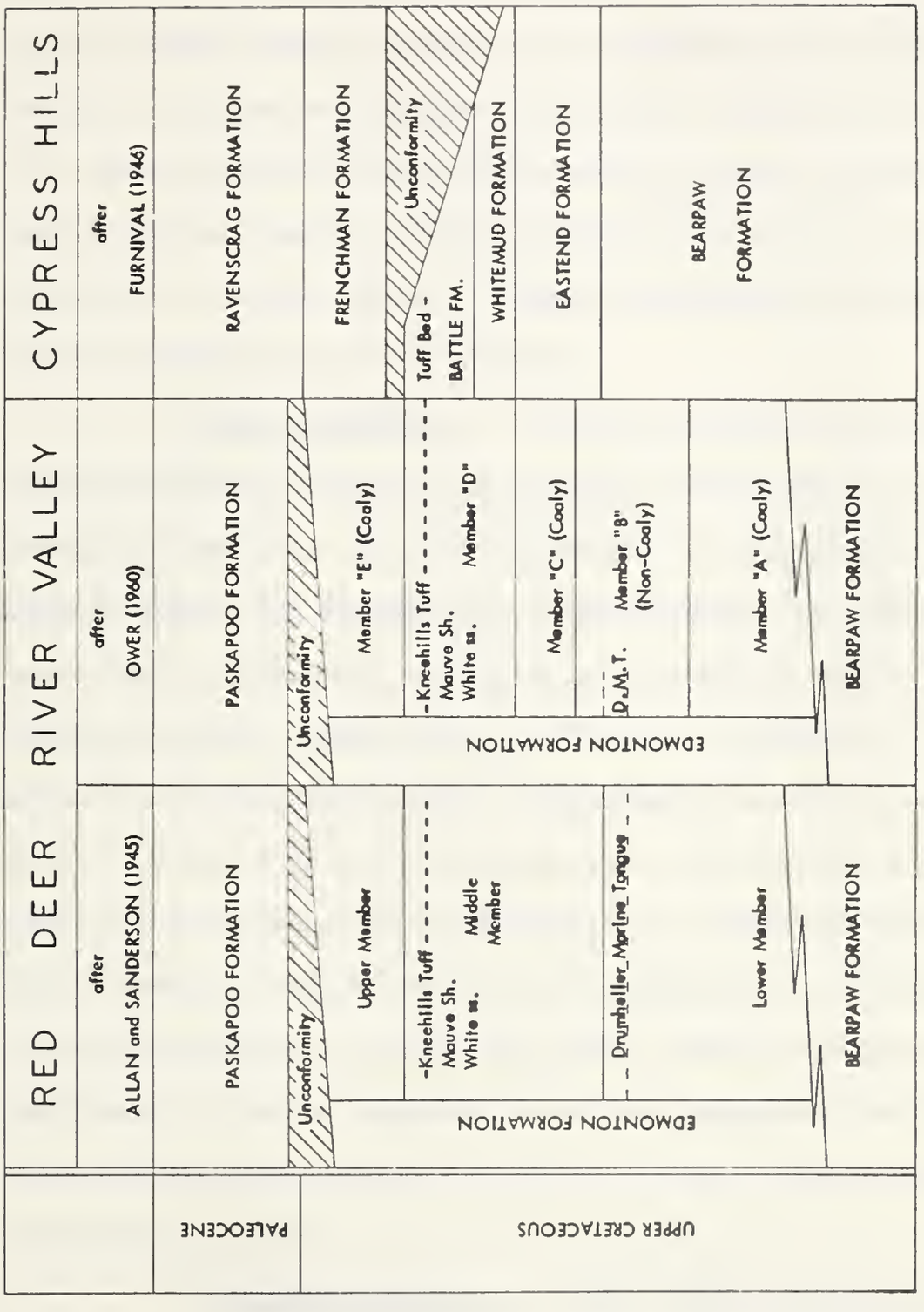

Figure 4: Stratigraphic correlation of the Edmonton Formation with the Upper Cretaceous strata of the Cypress Hills area (after J.D. Campbell, 1962).

Eastend Formation and underlies the dark shales of the Battle Formation. The Whitemud Formation can be traced in central Alberta as the "Whitemud" beds in the middle Edmonton below the Kneehills Tuff. The Whitemud Formation of the Cypress Hills consists of three subdivisions. The lower or sandy member is light grey or greenish-grey, medium- to coarse-grained, cross-bedded feldspathic sandstone, weathering white or pale. The average thickness of the lower member is about 35 feet. The middle member carries lignitic streaks and varies from 1 foot to 22 feet in thickness. The upper member contains predominantly a white kaolin clay and is commonly 30 to 36 feet thick.

Battle Formation: The Battle Formation conformably overlies the Whitemud Formation and underlies unconformably the sands of the Frenchman Formation. The Battle Formation is widespread in distribution. Furnival (1946) has divided it into two members. The lower member, consisting of bentonite, weathering dark chocolate-brown to black, and bentonitic shale, ranges from 5 to 30 feet in thickness. The upper member is greenish and includes interbedded olive-green to greenish grey shales, silts, up to 10 feet in outcrops. The bentonitic tuff layers have been correlated with the Kneehills Tuff (Campbell 1962) and the Battle Formation corresponds to the "Blackmud" beds of the Edmonton Formation according to Srivastava (1965). Well preserved silicified megaspores of similar morphology have been recovered from the Blackmud Member of the middle Edmonton division and the Battle Formation (Binda and Srivastava 1968).

Frenchman Formation: Davis (1918) defined the Ravenscrag Formation. McLearn (1929) and Fraser et al. (1935) divided it on lithological and faunal bases into the Upper and Lower Ravenscrag.

McLearn (1928, 1930) recognised an erosional unconformity at the base of the Lower Ravenscrag. Although Davis (1918) had originally included all the beds, above what is now the Battle Formation, in the Ravenscrag Formation, Furnival (1946) raised the Lower Ravenscrag to the status of a formation and applied the name Frenchman to it, reserving the name Ravenscrag to the upper portion only.

The coal-bearing Ravenscrag Formation (called Upper Ravenscrag by McLearn 1928, 1930) overlies the non-coaly Frenchman Formation. The upper contact is taken at the appearance of the first coal seam. Triceratops fauna characterises the Frenchman Formation. Lithologically, the Frenchman Formation consists of thick, massive or coarsely crossbedded, medium-grained sandstone with rare coaly beds. It is underlain by the Battle Formation and the contact is marked by a widespread erosional unconformity. Where erosion is insignificant, the beds of the Battle Formation grade into beds of the Frenchman Formation with only slight lithological changes. The contact is placed arbitrarily at the base of the lowest thick sandstone bed.

Campbell (1962) correlated the Frenchman Formation of the Cypress Hills with Ower's (1960) member "E" of the Edmonton Formation. Srivastava (1965) noted an erosional unconformity at the base of the upper Edmonton division which might correspond with the erosional unconformity at the base of the Frenchman Formation. However, the upper Edmonton member (sensu Allan and Sanderson 1945) or member "E" (sensu Ower 1960) can also be divided into two lithologic units, the lower of which i.e. the mammal-bone bearing member may be homotaxial with the Frenchman Formation.

CHAPTER IV - APPROACH TO THE PROBLEM

NOMENCLATURAL APPROACH

Species concept: The ecological-statistical polytypic concept defines the modern biospecies as "groups of actually or potentially interbreeding populations which are reproductively isolated from other such groups" (Cain 1954). Thus, theoretically, a neobotanical species may be separable from other such species on morphological, genetical, ecological, behavioural and breeding criteria. However, no practical criterion is absolute or universally applicable to fossil species; many of these criteria, such as breeding, can never be recognised in fossils. Consequently, a biospecies cannot be determined by the paleobotanist.

Paleobotanical species are "Linnean" species or morphospecies (Thomas 1956), i.e. species defined by morphological criteria. The morphospecies concept, based on arbitrary, morphological, non-genetical criteria, does not agree with the biospecies concept of a species as a discreet, non-arbitrary, clearly defined genetical entity. However, the identification of species largely remains morphological in both neobotany and paleobotany, and the approach of a neobotanist as identifier differs only in degree from that of a paleobotanist. In palynology also species are usually typological, nondimensional morphospecies (Stafleu 1967).

Hughes and Moody-Stuart (1967) rejected the prevailing typological concept of morphospecies in palynology and suggested replacement of the term 'species' applied to these with the term 'record'. The

introduction of the term 'record' seems superfluous as such groups are properly morphospecies. The limits of morphospecies are products of human perception; names applied to them enhance communication among the interested persons. According to George (1956):

> "a species --- is the creation of the systematist: a 'good' species is what a competent systematist considers to be a 'good' species; a species is what is conveniently a species; a species is as it is used; a species is not found, it is made".

The paleopalynological species should be both useful and practical. Paleopalynology has a major role in stratigraphy. The typological system of taxonomy is most suited to stratigraphy; in it a morphospecies becomes a fossil index of relative age.

A paleopalynologist may study an assemblage from a stratum and test it biometrically and statistically for homogeneity. Such tests may enable separation of statistical populations from the original assemblage. These populations, in turn, may contain more than one morphospecies. If tests discriminate among morphospecies in a series of collections from the same stratigraphical level at different localities, then the "species" population will be very near to the biospecies concept. However, Arkell (1956) pointed out that the genetical relationship or breeding potential nevertheless cannot be determined in such populations.

A species, based on morphological characteristics of assemblages collected from the same stratigraphic level throughout its geographic range, has been called holomorphospecies by Westoll (1956). Polytypic morphospecies (holomorphospecies) may be preserved in a continuously deposited and lithological uniform succession through time. Such an assemblage with dimension in time as well as space, is

called a chronospecies; the chronospecies may be very near the biospecies concept (Thomas 1956). Cain (1954) has called such species paleospecies. However, since it is impossible to demonstrate genetical continuity in time, conceptual conflicts and associated nomenclatural problems arise in dealing practically with paleospecies.

Naming the species: To achieve an international understanding and stabilization of nomenclature, rules are followed in naming species in spite of different species concepts; the rules are formalised in the International Code of Botanical Nomenclature, (Lanjouw et al. 1961).

Genus concept: The neobotanical genus concept is typological and nondimensional; both paleobotanists and paleopalynologists adhere to the concept in principle. The International Code of Botanical Nomenclature (Lanjouw et al. 1961) recognises three types of genera viz. "natural" genera, organ-genera, and form-genera. The uses of the latter two are restricted to fossil materials. An organ-genus is a genus assignable to a family; a form-genus is unassignable to a family, but it may be referable to a taxon of higher rank. Form genera are artificial in varying degrees. Stafleu (1967) discussed the implication of organ- and form-genera and questioned the validity and usefulness of the organ-genus as a category. He suggested a revised definition of the form-genus as quoted below:

> "A form-genus is a genus of fossil plants of which only relatively small but comparable parts are known (e.g., spores, pollen grains, fruits, leaf impressions). If the connection between these parts and the complete individual plants become known, the species of a form-genus may have to be considered as belonging to entirely different genera which need not even belong to the same family, order, or class. Form genera are therefore by definition artificial".

The suggested exclusion of 'the form-genus not being assignable to a family' eliminates the necessity to erect organ-genera and allows flexibility for assigning or not assigning form-genera to a family depending on the degree of confidence of the worker. Stafleu (1967) did not discuss the matter further, as the organ-genus is still recognised by the Code, but he has suggested suitable grounds for modification of its definition. However, many palynologists have taken the liberty to assign form-genera to families on the basis of morphological similarities among pollen.

The suggestions given by Faegri et al. (1950) are valuable for designating genera for fossil taxa and these should be closely followed by paleopalynologists.

Stafleu (1967) warned paleopalynologists against "unwarranted changes of names, disrespect of the rule of priority, incorrect retypification, adherence to page-priority and the like". In this context, it may be helpful to quote the admonition by Bhardwaj (1967):

> "The purpose of emendation of a taxon in biology is to correct faults or inaccuracies in circumscription and thus revise it accordingly. In the type-method of taxonomic circumscription, new information on the morphology and organisation of the types of a taxon (if it is significantly different from the one hitherto known) necessitates emendation. But in practice, emendations of older taxa are being suggested by many palynologists without any reference to the types. In many cases, the need for such emendations is either to include one's own specimens forcibly into an older genus (thus circumventing taxonomic indecision) or, sometimes, to give shape to a phylogenetic speculation. Emendation should not be resorted to unless one has noticed a discrepancy in the morphographic description of the types and the constituents after a personal study of the types or, if good descriptions and photographs are available, after critical analysis of the evidence, as compared to that supposed to be true by the original authors. Emendation is also justified if some new phylogenetic evidence (not speculation) has become available necessitating separation of a part of a taxon, or the amalgamation of a number of taxa, and thus, a redefinition of a diagnosis".

In the present project, the nomenclatural problem has been approached along the lines discussed above. The taxa used are form-species and form-genera, and have been named, diagnosed or circumscribed according to the International Code of Botanical Nomenclature (Lanjouw et al. 1961).

The form-genera that could be related to families have been grouped under them, and others, which have doubtful relations with modern families, have been classified as having uncertain affinity. No attempt has been made to refer taxa to higher categories; no useful purpose would be served by doing so. The inclusion of form-genera in certain modern families indicates only the morphological similarity of the fossil pollen to the pollen of the families. Binding a form-genus to higher rank would be superfluous until its relation with a family has been definitely established. The hierarchy proposed by Potonié and Kremp (1954) has not proved to be useful here, as many times morphographically similar pollen classified under the same rank are remotely related in nature; such a hierarchy would have posed difficulties in interpreting paleoecology.

STATISTICAL APPROACH

The foundation of present day paleopalynology was laid in 1916 when Lennart von Post presented the first pollen diagram at the Sixteenth Scandinavian Meeting of Natural Scientists in Christiania (now Oslo). This paper showed that pollen occurrences could be represented graphically, thereby making palynology an effective tool in stratigraphy and paleoecology. The optimism concerning graphical representation of pollen arose, in part, from assumptions that have

since been shown to be false; it was assumed, for example, that pollen were uniformly transported and preserved. Various reservations were expressed from time to time about methods of statistical analysis of pollen, but the optimistic attitude towards the utility of fossil pollen remained very much the same. Recent studies showing misrepresentation of pollen flora in sediments (Davis 1963; Davis and Goodlett 1960), differential pollen preservation under different conditions (Sangster and Dale 1961, 1964), nonpreservation of pollen (Erdtman 1943, 1952), differential transportability of pollen in relation to the types of pollen and distances of their sources from the depositional site (Erdtman 1943), and the role of water in transportation, sedimentation and preservation of pollen (Muller 1959; Traverse and Ginsburg 1966, 1967; Cross, Thompson and Zeitzeff 1966) have forced palynologists to change their customary statistical approaches.

Jekhowsky (1958) recognised 11 form-groups based on morphological characteristics and used their frequency distribution to distinguish and correlate zones in a formation. Nagy (1960) condensed the main microscopic forms into eight morphological units and used the resulting frequency graphs for zonation and correlation. This system has been followed by Crickmay and Pocock (1963) in correlating Cretaceous sediments of Vancouver Island, British Columbia (Canada). They divided their pollen assemblages into ten broad categories to plot histograms and vertical variability diagrams. However, occurrences of quantified broad morphological units in a sample cannot be treated as more than lithological constituents. The constituents may represent microfloral facies and not evolutionary advances; hence they cannot be used for indicating time planes. For example at the same time plane, a sandy

shale sample yields fewer microspores than an argillaceous shale; these would not be correlative under broad quantified morphological unit concepts.

Morphospecies may be based on morphological criteria which are very much refined. It is assumed that a morphospecies of pollen belonged to only one homogenous population of individuals which shared similar ecological conditions and other characteristics. "Absolute presence" of a qualitative and nonstatistical species is the most valuable datum for age determination, zonation or correlation.

Faegri (1966) commented on some problems of representation in pollen analysis of Quaternary pollen. The following comments from him are of a general nature and applicable here:

> " ... One of the major snags is that if statistical methods are used to check upon a result (i.e. pollen spectrum) which is, for some reason or other, outstanding, there is already bias in the material which invalidates the assumption on which the statistical treatment is based. On the other hand, if the whole sequence is subjected to an unbiased statistical check of this kind, the only thing that can come out of it is the establishment that an outstanding sample is outstanding - which anybody could see for themselves. True one may find that probability values are extremely low, but again, this may be the one green pea among a thousand yellow ones. Sooner or later it turns up.
>
> It should be kept in mind that statistics can never give absolute answers, only answers in terms of probabilities, and even if probabilities are very low, they are never exclusive. Biology is full of examples of improbabilities come true; after all, it would be very easy to prove that the origin of life itself is a 'statistical impossibility'."

It is doubtful that evolution in plants has taken place in parallel to pollen forrow conditions such as tricolpate going to tricolporate and triporate state. Hence it is doubtful that colpate and porate conditions represent a particular time plane, as such. Similarly, it is improbable that floral changes of a region will be guided by evolution of colpate conditions.

The introduction of a species represented by a single pollen in a sample should be sufficient to mark the absolute presence of that species and to indicate a time plane. The abundance and impoverishment of a species is dependent on multiple variables such as transportability, preservation, productivity of pollen during the deposition of the sediments in which it was preserved and the subsequent lithological development of those sediments. Thus the broadly quantitative data shown in pollen spectra will be useful only to distinguish palynofacies in a restricted region. Such quantification may be followed only by broad qualitatives, such as "poor", "good", "abundant" etc. to give an idea of similar palynofacies. This approach has been followed in this project. For inter-regional correlations or age determination, only absolute presence of a species is useful.

STRATIGRAPHICAL APPROACH

The criterion of absolute presence has been followed in this study. The term "absolute presence" in the present context denotes the presence of a species in a sample. The appearances of different species are taken as indicators of the time of their introduction in the area. Nonfactual or negative evidence has not been used.

The concept of assemblage zone has been followed according to the Code of Stratigraphic Nomenclature proposed by the American Commission on Stratigraphic Nomenclature (1961); in the Code an assemblage zone is defined as "a body of strata characterised by certain assemblages of fossils without regard to their ranges; it receives its name from one or more of these fossils". The assemblage zones are recognised here on the basis of variation in the fossil taxa among assemblages. Assemblages,

on which the zones are based, are defined. These have been named from one or more diagnostic taxa. Subzones within the assemblage zones have also been recognised wherever possible.

PALEOECOLOGICAL APPROACH

Pre-Quaternary pollen can be related to modern species or genera with a relatively poor degree of confidence. The relationship is a direct one; the older the strata, the less the confidence. Following the law of uniformitarianism, it has been assumed that the plants which produced fossil pollen resembling the pollen of modern taxa might have had habitats similar to modern taxa. In the present project, although pollen have been classified as form-genera and form-species, their morphological affinities with the modern flora have been suggested when possible. When the certainty about the morphological affinity of fossil taxa with modern ones is convincing, these have been grouped within modern families. From evidence provided by the ecological conditions in which the modern families are distributed, the paleoecology of the fossil taxa has been inferred.

CHAPTER V - BIOSTRATIGRAPHY

Biotic development is a continuous process, ramifying in time and space. Only fragments of the biotic continuum are preserved in the strata. Any division of the fossil record in space or time becomes arbitrary, suiting the needs of the problem. For stratigraphic purposes, the biotic content of a rock is assumed to represent contemporaneity with the containing sediments. Vertically and laterally (time and space respectively), strata may be discriminated by the changes in biotic assemblages of the rocks. Thus a discriminated set of strata is characterised by a specific biotic spectrum and may be called an assemblage zone. Initially, an assemblage zone is local but may be extended laterally with the help of the diagnostic biota.

The assemblage zone concept as outlined by the Code of Stratigraphic Nomenclature (American Commission on Stratigraphic Nomenclature, 1961) has been followed in recognising various horizons of the Edmonton Formation.

Nine assemblage zones are recognised in the sections of the Edmonton Formation in the Red Deer River Valley between Scollard and Drumheller studied here. A formal description with the characteristic angiosperm pollen of each assemblage zone is given in the following pages, starting with the oldest.

THE TRANSITIONAL ZONE (I)

Figures 9, 18, 19.

REFERENCE LOCALITY: East Coulee, sec. 27, twp. 27, rge. 18, W. 4th mer., Alberta, Canada.

VERTICAL EXTENSION: From the base of the Edmonton Formation up to the top of a 12 feet thick massive sandstone underlying a two feet thick shale bed. The total thickness of the zone is about 88 feet at East Coulee, Alberta.

LITHOLOGY: Thin bedded brown shales alternating with fine sandstones and a thick massive sandstone strata at the top.

SPECIES APPEARED: Erdtmanipollis pachysandroides, Polyporina cribraria, Coriaripites alienus, Caryapollenites paleocenicus, Cranwellia bacata, Myricipites dubius, Anacolocidites insignis, Fraxinoipollenites variabilis, Monosulcites gemmatus, Tricolpites microreticulatus, T. mtchedlishviliae, Pulcheripollenites narcissus, Wilsonipites nevisensis, Scabrastephanocolpites lepidus, Aquilapollenites catenireticulatus, A. mirabilis, A. stelckii, A. accipiteris, A. aptus, A. drumhellerensis, A. sentus, A. polaris.

SPECIES RESTRICTED: Anacolocidites insignis, Aquilapollenites catenireticulatus, A. stelckii.

REMARKS: The restricted species in this zone occur at the base only. Erdtmanipollis pachysandroides, Coriaripites alienus, Tricolpites microreticulatus, Wilsonipites nevisensis, Scabrastephanocolpites lepidus, Aquilapollenites accipiteris and A. polaris occur throughout the Edmonton Formation. These species seem to be long ranging and may be well established elements of an earlier flora. The marine Bearpaw shale below would tend to mask the continuity of continental taxa.

New elements appear gradually. Comparative impoverishment of the microflora may be partly due to the increased sand content in the upper beds of this zone. The microflora is associated with Azolla glochidia and marine microplankton also.

THE AQUILAPOLLENITES LEUCOCEPHALUS ZONE (II)

Figures 9, 18, 19.

REFERENCE LOCALITY: East Coulee, sec. 27, twp. 27, rge. 18, W. 4th mer., Alberta, Canada.

VERTICAL EXTENSION: At the base of the zone is a 2 feet thick shale bed about 88 feet above the top of the Bearpaw shale at East Coulee. The top of the zone underlies the basal shales of a coal seam exposed at the top of the East Coulee section. The total thickness of this zone is 86 feet.

LITHOLOGY: Thin bedded shales alternating with massive, thick, white sandstones.

SPECIES APPEARED: Liliacidites mirus, Rhoipites crassus, Quercoidites sternbergii, Cranwellia rumseyensis, Zonosulcites scollardensis, Nyssapollenites bindae, Nyssoidites ingentipollinus, Beaupreaidites occulatus, Proteacidites thalmannii, Ailanthipites cupideneus, A. potoniei, Trifossapollenites ellipticus, Tricolpites occidentalis, T. vulgaris, Margocolporites taylorii, Senipites drumhellerensis, Scabrastephanocolpites albertensis, Aquilapollenites debilis, A. leucocephalus, A. medeis, A. funkhouseri, A. reductus, A. augustus, A. pudicus, A. amplus, A. granulatus, A. insignis, A. decorus, A. macgregorii, Mancicorpus albertensis, M. anchoriforme, M. solidus, Mtchedlishvilia canadiana.

SPECIES RESTRICTED: Scabrastephanocolpites albertensis, Aquilapollenites debilis, A. leucocephalus, Mancicorpus anchoriforme, M. solidus.

REMARKS: This zone is dominated by massive white sandstones with a few thin bands of argillaceous shales. These shales contain

abundant microspores. Most of the 33 species introducted in this zone are long ranging.

Among the five restricted species of this zone, three are significant viz. Aquilapollenites leucocephalus, Mancicorpus anchoriforme and M. solidus. Aquilapollenites leucocephalus appears in sample EC6 and floods in sample EC7. It does not appear again in the Edmonton Formation.

Mancicorpus anchoriforme and M. solidus occur only in sample EC5. Occurrence of M. anchoriforme is abundant while M. solidus is rare. Both species have been reported from the Maestrichtian strata of Siberia also (Samoilovitch and Mtchedlishvili 1961).

THE WODEHOUSEA JACUTENSE AND W. GRACILE ZONE (III)

Figures 9, 10, 18, 19.

REFERENCE LOCALITY: East Coulee, sec. 27, twp. 27, rge. 18, W. 4th mer., and Drumheller, sec. 24-25, twp. 29, rge. 21, W. 4th mer., Alberta, Canada.

VERTICAL EXTENSION: A 5 feet thick coal seam with basal brown shale is exposed at the top of the East Coulee section. This seam marks the base of this zone (III) and is the lateral equivalent of a carbonaceous shale exposed at the water level on Red Deer River in the Drumheller section. The top of the zone is about 60 feet above the water level in the Drumheller section underlying a 5 feet thick coal seam exposed just below the level of the main road about 2 miles west of the "Little Church". The total thickness of this zone is about 60 feet.

LITHOLOGY: Bentonitic sandstone, shales and ironstone bands are the main lithological units of this zone.

SPECIES APPEARED: Liliacidites morrinensis, Carpinites ancipites, Ilexpollenites obscuricostatus, Nyssapollenites parvus, Nyssoidites edmontonensis, Beaupreaidites angulatus, B. libitus, Proteacidites auratus, Symplocoipollenites morrinensis, Monosulcites drumhellerensis, M. echinatus, Stelckia vera, S. unica, S. xenoforma, Tubilifloridites aedicula, Grewipollenites canadensis, Pulcheripollenites inrasus, Aquilapollenites amicus, A. amygdaloides, A. antigonei, A. oblatus, A. validus, A. venustus, A. dolium, A. ascriptivus, A. comosus, A. hirsutus, A. hispidus, A. paplionis, A. pumilis, A. regalis, A. stellatus, A. asper, A. spinulosus, A. alveolatus, Mancicorpus rostratus, M. senonicus, Wodehousea gracile, W. jacutense, cf. Orbiculapollis globosus, Loranthacites catterallii.

SPECIES RESTRICTED: Monosulcites echinatus, Stelckia vera, S. unica, S. xenoforma, Tubilifloridites aedicula, Aquilapollenites amicus, A. amygdaloides, A. antigonei, A. stellatus, A. alveolatus, Wodehousea gracile, W. jacutense, cf. Orbiculapollis globosus.

REMARKS: Argillaceous shales and bentonitic sandstones are prevalent in this zone. A prolific microflora has been recovered from this zone. Forty angiosperm species appeared, many belonging to the genus Aquilapollenites. A. amicus, A. amygdaloides and A. antigonei are restricted in this zone. A. stellatus with four equatorial projections has a rare occurrence.

Genus Stelckia with its characteristic asymmetrical colpi appeared at this level. Wodehousea gracilie and W. jacutense occur abundantly throughout the zone and are restricted therein. These two species of Wodehousea are reported from the Maestrichtian strata of Siberia also (Samoilovitch and Mtchedlishvili 1961).

The appearance of Beaupreaidites angulatus, B. libitus and Proteacidites auratus indicates the introduction of proteaceous elements at this level.

THE PULCHERIPOLLENITES KREMPII ZONE (IV)

Figures 10-13, 18, 19.

REFERENCE LOCALITY: Drumheller, sec. 25, twp. 29, rge. 21, W. 4th mer., Alberta, Canada.

VERTICAL EXTENSION: From the base of the 5 feet thick coal seam exposed under the main road in the Drumheller section (about 2 miles west of the "Little Church") up to the base of a massive, white sandstone lying about 60 feet below the prairie level. The total thickness of this zone is about 210 feet.

LITHOLOGY: Thin sandstones, shales, ironstones and coal seams occur in this zone.

SPECIES APPEARED: Liliacidites variegatus, Alnipollenites finitimus, Faguspollenites granulatus, Proteacidites tumidiporus var. ecollariatus, Rhamnacidites minutapollenites, Rousea subtilis, Talisiipites fisheri, Nothopollenites primus, Pulcheripollenites krempii, Callistopollenites radiatostriatus, C. comis, C. tumidoporus, Tetracolpites pulcher, Erdtmania superba, Marcellopites tolmanensis, M. basilicus, Aquilapollenites ceriocorpus, A. firmus, A. petasus, A. vinosus, A. minutus, Mancicorpus borealis.

SPECIES RESTRICTED: Faguspollenites granulatus, Proteacidites tumidiporus var. ecollariatus, Rhamnacidites minutapollenites, Rousea subtilis, Talisiipites fischeri, Nothopollenites primus, Pulcheripollenites krempii, Callistopollenites radiatostriatus, C. comis, C. tumidoporus,

Tetracolpites pulcher, Erdtmania superba, Marcellopites tolmanensis, M. basilicus, Aquilapollenites firmus, A. petasus, A. vinosus, Mancicorpus borealis.

REMARKS: Most of the earlier microflora continued with the new appearance of 22 angiosperm species. The microfloral assemblage of this zone is prolific both in quantity and quality.

Several species of Aquilapollenites are introduced in this zone. A. petasus is another species with four equatorial projections appearing at this level. The species of Pulcheripollenites which appeared in the Wodehousea jacutense and W. gracile Zone continued to occur in this zone also with the addition of Pulcheripollenites krempii. Another morphologically allied genus Callistopollenites appears here. C. radiatostriatus, C. comis, and C. tumidoporus are restricted in this zone.

The occurrence of proteaceous elements continued with the introduction of Proteacidites tumidiporus var. ecollariatus which has been reported from the Maestrichtian of Siberia also (Samoilovitch and Mtchedlishvili 1961).

Thicknesses of 36 feet and 114 feet of the Pulcheripollenites krempii Zone have been recognised underlying the lower oyster bed in the Horseshoe Canyon and Morrin Bridge sections respectively. The oyster beds themselves are not located in the Betty Tolman section but on the basis of the microfloral change a 110 feet thickness of the Pulcheripollenites krempii Zone is recognised at the base of the Betty Tolman section up to the sample no. BT19 (Fig. 13).

THE MANCICORPUS BOREALIS SUBZONE (IVa)

Figures 10, 18, 19.

REFERENCE LOCALITY: Drumheller, sec. 25, twp. 29, rge. 21, W. 4th mer., Alberta, Canada.

VERTICAL EXTENSION: From the base of the Pulcheripollenites krempii Zone up to the top of the shale bed underlying a 6 feet thick sandstone strata. The total thickness of the zone is 26 feet in the Drumheller section.

LITHOLOGY: Coal seam at the base, argillaceous and arenaceous shales, and occasional thin ironstone bands.

SPECIES APPEARED: Rhamnacidites minutapollenites, Rousea subtilis, Pulcheripollenites krempii, Callistopollenites radiatostriatus, C. comis, Erdtmania superba, Aquilapollenites firmus, Mancicorpus borealis.

SPECIES RESTRICTED: Rhamnacidites minutapollenites, Aquilapollenites firmus, Mancicorpus borealis.

REMARKS: The Mancicorpus borealis Subzone is distinguished by the presence of Mancicorpus borealis throughout the subzone. It does not recur in any other part of the Edmonton Formation studied here. The Horseshoe Canyon, Morrin Bridge and Betty Tolman sections are at a higher level than the Mancicorpus borealis Subzone recognised at Drumheller.

THE MANCICORPUS VANCAMPOI ZONE (V)

Figures 11-15, 18, 19.

REFERENCE LOCALITY: Tolman Crossing (Betty Tolman Section), sec. 12, twp. 33, rge. 22, W. 4th mer., Alberta Canada.

VERTICAL EXTENSION: From sample no. BT19 (110' above water

level) to the top of the bedrock section below prairie level in the Betty Tolman section. The total thickness of the zone is about 146 feet here.

LITHOLOGY: Mostly arenaceous shales, massive white sandstones, siltstones and thin ironstone bands are present. A 2 feet thick coal seam lies at the top of this zone.

SPECIES APPEARED: Erdtmanipollis procumbentiformis, Cranwellia asperata, Loranthacites pilatus, Disulcites magnus, Mancicorpus vancampoi.

SPECIES RESTRICTED: Same as mentioned in "species appeared".

REMARKS: Five angiosperm species appeared in this zone and have a rare occurrence. Mancicorpus vancampoi occurs throughout the zone. Several species which were introduced earlier in zones I, II, III and IV do not occur in this zone or afterwards in the rest of the Edmonton Formation.

Nonpreservation in the arenaceous sediments of this zone, may be one of the causes for the paucity of microflora in many of the samples. However, the argillaceous and carbonaceous samples yielded a rich microflora which represents the contemporaneous flora.

This zone is characterised by the presence of Mancicorpus vancampoi in its microflora. The basal part of this zone has been recognised overlying the lower oyster bed in the Horseshoe Canyon and Morrin Bridge sections (Figs. 11, 12). The upper part of the zone has been traced in Scollard Localities 18 and 1 also (Figs. 14, 15).

THE SCOLLARDIA TRAPAFORMIS ZONE (VI)

Figures 14, 15, 18, 19.

REFERENCE LOCALITY: Scollard Locality 1, sec. 18, twp. 34, rge. 21, W. 4th mer., Alberta, Canada.

VERTICAL EXTENSION: From the top of the Mancicorpus vancampoi Zone in the Scollard Locality 1 (sample no. Sc 1-25) up to the sample 5 feet above a coal seam (sample no. Sc 1-16) lying 47 feet below the Kneehills Tuff in the Scollard Locality 1.

LITHOLOGY: Thin sandstone strata, lignitic and carbonaceous shales, and coal.

SPECIES APPEARED: Cranwellia edmontonensis, C. striata, Ulmipollenites planeraeformis, Scollardia trapaformis, S. steevesii, S. nortonii, Aquilapollenites aucellatus, Mancicorpus gibbus.

SPECIES RESTRICTED: Cranwellia edmontonensis, Scollardia trapaformis, S. steevesii, S. nortonii, Aquilapollenites aucellatus, Mancicorpus gibbus.

REMARKS: Eight species appeared, out of which six terminate within the zone. Most of the samples are argillaceous, lignitic or coaly and yielded a rich microflora.

Genus Scollardia and Mancicorpus gibbus are diagnostic elements of this zone. Except for a few persistent long ranging species, almost all angiosperm species terminated either in this zone or above it.

The Scollardia trapaformis Zone has been recognised in the Scollard Locality 18, from sample no. Sc 18-24 to Sc 18-20 with a thickness of 17 feet.

THE *MANCICORPUS GIBBUS* SUBZONE (VIa)

Figures 14, 15, 17-19.

REFERENCE LOCALITY: Scollard Locality 1, sec. 18, twp. 34, rge. 21, W. 4th mer., Alberta, Canada.

VERTICAL EXTENSION: From the top of the *Mancicorpus vancampoi* Zone in the Scollard Locality 1 (sample no. Sc 1-25) up to Sc 1-23. The total thickness of the zone is about 12 feet in the Scollard Locality 1.

LITHOLOGY: Argillaceous sandstones with thin arenaceous shaly bands.

SPECIES APPEARED: *Cranwellia edmontonensis*, *C. striata*, *Scollardia trapaformis*, *S. steevesii*, *S. nortonii*, *Mancicorpus gibbus*.

SPECIES RESTRICTED: *Mancicorpus gibbus*.

REMARKS: This subzone is recognised by the restricted occurrence of *Mancicorpus gibbus*. The *Mancicorpus gibbus* Subzone is traced in the Cypress Hills section also (Figure 17) which is about 250 miles south of the Scollard sections. Its recognition in the Cypress Hills gives an optimistic index marker value to *M. gibbus* in the regional stratigraphy.

THE *AZOLLA* AND *BALMEISPORITES*-BEARING INTERVAL (VII)

Figures 14, 15, 18, 19.

REFERENCE LOCALITY: Scollard Locality 18, sec. 20, twp. 34, rge. 21, W. 4th mer., Alberta, Canada.

VERTICAL EXTENSION: From the top of the coal seam 34 feet below the Kneehills Tuff (about 1 foot thick) to sample no. Sc 18-14, about 14 feet below the Kneehills Tuff. The total thickness of this

zone is 20 feet in the Scollard Locality 18.

LITHOLOGY: Argillaceous, bentonitic sandstones and siltstones.

REMARKS: Only megaspores of Azolla and Balmeisporites, which extend throughout the formation, are recovered from this zone. Impoverishment of microspores may be due to some nonpreservative conditions of the strata. An increase in bentonitic content might have a destructive effect on organic microfossils.

THE WODEHOUSEA SPINATA ZONE (VIII)

Figures 14-16, 18, 19.

REFERENCE LOCALITIES: Scollard Locality 18, sec. 20, twp. 34, rge. 21, and Scollard Locality 1 and 2, sec. 18, twp. 34, rge. 21, W. 4th mer., Alberta, Canada.

VERTICAL EXTENSION: From the base of the Blackmud Member of the Edmonton Formation in the Scollard Locality 18 at sample no. Sc 18-14 up to the top of the Nevis coal seam in the Scollard Locality 2 at sample no. Sc 2-6. The total thickness of the zone is about 162 feet in the Scollard area.

LITHOLOGY: Bentonitic argillaceous shales, sandstones - sometime with coaly streaks and coal.

SPECIES APPEARED: Cranwellia fida, Aquilapollenites barbatus, A. conatus, Wodehousea spinata, Polycolpites pocockii, Tetracolpites reticulatus.

SPECIES RESTRICTED: As mentioned above in "species appeared".

REMARKS: This zone is characterised by only a few long ranging angiosperm species. The species which appeared at this level also

terminated within the zone. Wodehousea spinata and Polycolpites pocockii have a common occurrence. The number of angiosperm species is very low compared to the gymnosperms and pteridophytes present in the microflora recovered from this zone.

THE POLYCOLPITES POCOCKII SUBZONE (VIIIa)

Figures 16, 18, 19.

REFERENCE LOCALITY: Scollard Locality 2, sec. 18, twp. 34, rge. 21, W. 4th mer., Alberta, Canada.

VERTICAL EXTENSION: From the top of an ironstone band about 85 feet above the Kneehills Tuff (sample no. Sc 2-C_1) up to the top of the Nevis coal seam i.e. sample no. Sc 2-6 in the Scollard Locality 2. The total thickness is 56 feet in the Scollard Locality 2.

LITHOLOGY: Sandstones, siltstones, shales, thin ironstone bands and coal.

SPECIES APPEARED: Aquilapollenites barbatus, A. conatus, Polycolpites pocockii and Tetracolpites reticulatus.

SPECIES RESTRICTED: Same as mentioned above in "species appeared".

REMARKS: The Polycolpites pocockii Subzone is recognised by the presence of P. pocockii in the Wodehousea spinata Zone of the Scollard Locality 2.

THE WODEHOUSEA FIMBRIATA ZONE (IX)

Figures 16, 18, 19.

REFERENCE LOCALITY: Scollard Locality 2, sec. 18, twp. 34,

rge. 21, W. 4th mer., Alberta, Canada.

VERTICAL EXTENSION: Only the base of this zone has been recognised overlying the Nevis coal seam in Scollard Locality 2.

LITHOLOGY: The basal portion consists of alternating sandstone and shale strata.

SPECIES APPEARED: Wodehousea fimbriata.

REMARKS: The base of the Wodehousea fimbriata Zone is recognised by the appearance of W. fimbriata in sample no. Sc 2-7.

W. fimbriata has been reported from the Maestrichtian to the Lower Paleocene strata of Siberia (Samoilovitch and Mtchedlishvili 1961) and from the Lower Paleocene of U.S.A. (Stanley 1965; Norton and Hall 1967). The microfloral assemblage of this zone is comparable with the microflora of Zone "B" described by Snead (1968) from the Red Deer Valley, Alberta.

CHAPTER VI - PALEOECOLOGY

The variation within the angiosperm microflora throughout the sedimentary sequence has been used for the biostratigraphic zonation of the Edmonton Formation. The microfloral change reflects the variation in the contemporaneous source flora. These changes must have been brought about by evolutionary or ecological factors. In this chapter, the environment of the Edmonton flora is interpreted principally through the analysis of microfossils recovered from these same strata.

Analogy and homology of the fossil flora to extant flora is the basis for these paleoecological interpretations. However, fossil pollen in sediments are contributed by various floral sources around the depositional site. Thus a pollen-spectrum of the strata represents a collective but partial flora of the region. Many variables such as productivity, transportability and preservation of pollen may distort the presentation of the actual flora. Thus the paleoecological conclusions are generalized and restricted to the region discussed.

The climate of an area is responsible in part for determining the flora of the region. Conversely the flora of an area may be an index of the prevailing climate. However, this relation between climate and vegetation depends on the definition of "climate". Loosely defined, climate is a composite or generalization of the variety of day-to-day weather conditions which are a combination of several elements such as temperature, precipitation and humidity, winds, and air pressure (Trewartha 1954). All these factors remaining constant, the vegetation of an area may still change due to various edaphic factors or the availability of water to plants.

Application of physically defined climatic classifications

is not useful for microfossil studies. Such climatic classifications like one proposed by Köppen (1936) are based upon annual and monthly means of temperature and precipitation. Köppen looked upon the native vegetation as the best expression of overall climate. Many of the climatic boundaries have been selected with the vegetation limits in mind while others are purely arbitrary choices. His rigid boundary criteria for climatic classification has not been found satisfactory for even modern climates. Köppen has been criticised for applying the same formulae for higher altitudes which he derived for lowland climates (Trewartha 1954). Köppen's classification cannot be used for the interpretation of paleoecology through microfossils due to the following reasons:

1. A composite flora of the region is determined through the microfossils.
2. The distribution of modern flora is not known according to Köppen's classification.

For paleoclimatic interpretations through microfossils, a classification is needed where vegetation has been used as an index. Thornthwaite (1931) devised such a classification but it has a complicated and impractical system of determining boundaries of various climates.

Flohn (1950) gave a semigenetic classification of climate. He differentiated seven climatic zones based particularly on precipitation. He indicated typical vegetation forms also for each climatic zone. However, these zones are qualified by wind pressure, wind belts, and prevailing winds in different seasons. These latter factors will not be available for interpretation through the microfossil evidence.

Trewartha (1954) modified and simplified Köppen's classification compromising both genetic and physical bases. It is actually a more refined classification on the pattern of the classical climatic classification into temperate, subtropical and tropical groups. Most of the information about the distribution of modern plants is available in terms of tropical, subtropical and temperate climates. Thus paleoclimatic interpretations will have to depend largely on such information. However, when detailed information is available, Trewartha's classification has been applied on the basis of index vegetation of that zone rather than by their defined physical boundaries. However, all these classifications, devised for classroom teaching, are not suitable for practical application.

In Chapter V, nine microfloral zones are recognised from the Edmonton Formation. The physical change in the microflora from one level to the other has already been discussed. The ecological interpretation of the microflora of each zone is discussed below starting from the oldest to the youngest zone of the Edmonton Formation.

ECOLOGY OF THE TRANSITION ZONE (I)

The Transition Zone of the Edmonton Formation marks the regression of the Bearpaw sea. Twenty-two angiosperm species appeared in this zone. Many of them are long ranging and three species are restricted in this zone. Species occurring at this level have affinity with the families - namely Buxaceae, Chenopodiaceae, Coriariaceae, Juglandaceae, Loranthaceae, Myricaceae, Oleaceae and Hamamelidaceae. Affinities of genera Pulcheripollenites and Aquilapollenites are not certain. However, certain members of Lythraceae produce pollen somewhat

resembling Pulcheripollenites. The general shape and structure of Aquilapollenites resemble pollen of Proteaceae (Simpson 1961), Dipsacaceae (Rouse 1957) and Santalaceae (Funkhouser 1961).

The occurrence of chenopodiaceous Polyporina cribraria is interesting. Most of the modern members of family Chenopodiaceae are halophytes - often characteristic of salt marshes. Their occurrence in sediments may indicate changes in the shore line (Erdtman 1943, p. 82). Sometimes pollen of Chenopodiaceae may indicate aridity also (Deevey 1937). However, the occurrence of Polyporina cribraria in the Transition Zone of the Edmonton Formation is associated with marine microplankton, Azolla glochidia and megaspores. Azolla grows in stagnant fresh-water ponds and marshes and its glochidia and megaspores cannot be transported by wind. Hence the area near the deposition should be humid rather than arid. The proximity of sea is indicated by the presence of marine microplankton. Thus in this case, P. cribraria indicates the shifting shore line of the sea.

New elements appear gradually in this zone which indicates the advancing and developing nature of vegetation into the area vacated by the regressing sea.

In the Transition Zone, a free mixing of fresh and marine water was taking place. Azolla might have been carried by fresh-water channels to the depositional site. Occurrence of microplankton is indicative of a marine environment. An establishing vegetation on a marshy area having a stagnant paludal environment with the proximity of an infringing sea is indicated. The microflora indicates a prevalent subtropical humid climate.

ECOLOGY OF THE *AQUILAPOLLENITES LEUCOCEPHALUS* ZONE (II)

Forty-eight angiosperm species are recorded from the *Aquilapollenites leucocephalus* Zone. 33 species have been introduced at this level which belong to family Liliaceae, Anacardiaceae, Fagaceae, Loranthaceae, Nymphaeaceae, Nyssaceae, Proteaceae, Simaroubaceae, Hamamelidaceae and Symplocaceae. The genus *Quercoidites*, having morphological affinity with *Quercus* pollen, is attributed to the family Fagaceae. *Quercus* is a temperate genus. Family Anacardiaceae, Nyssaceae and Proteaceae have their modern distribution in tropical areas. The other remaining families are distributed in tropical to subtropical climate.

Several species of *Aquilapollenites* and *Mancicorpus* have also appeared in this zone. *Azolla* and *Balmeisporites* occur in abundance.

Occurrence of proteaceous pollen in these strata is significant. In modern distribution, Proteaceae are restricted in tropical Southern Hemisphere, tropical Asia and Malaysia. The majority of Proteaceae members are distributed in regions having a long annual dry season. Thus they are mostly xerophytic. However, the primitive members of the family are largely rain-forest trees. Therefore, xerophily is probably a secondary character (Willis 1966). The occurrence of proteaceous pollen in this zone may be indicative of a humid climate rather than an arid one.

Introduction of several arboreal species in the microflora of the *Aquilapollenites leucocephalus* Zone indicates the formation of woodland vegetation with the dominance of tropical and subtropical elements near the sedimentation. Abundance of water-ferns and aquatic angiosperms (family Nymphaeaceae) is indicative of marshes and fresh-water

ponds in the area. Quercus is a temperate genus. The rare presence of Quercoidites in this zone indicates a temperate element in the flora. Quercus produces large quantities of pollen which can be transported to long distances by wind. However, Quercus pollen do not preserve well. Thus such pollen might be contributed from a distant source with cooler climate. Sometime Quercus appears in subtropical vegetation also. Thus the possibility of such a source within local vegetation cannot be ruled out. Then the rarity of Quercoidites would be due to its nonpreservation.

The Aquilapollenites leucocephalus Zone was deposited in paludal conditions under the influence of a subtropical humid climate.

ECOLOGY OF THE WODEHOUSEA JACUTENSE AND W. GRACILE ZONE (III)

76 angiosperm species are identified from the W. jacutense and W. gracile Zone. 41 species have entered at this level, others have extended from the earlier zones. Among the new elements, the majority belongs to genera Aquilapollenites, Mancicorpus, Stelckia, and Wodehousea whose affinities are not certain. Grewipollenites and Pulcheripollenites have an apparent morphological similarity with Lythraceae pollen. Other species appearing in this zone represent the families Liliaceae, Carpinaceae, Aquifoliaceae, Nyssaceae, Proteaceae and Symplocaceae.

Carpinaceae are temperate and widely distributed in the Northern Hemisphere. All the members of Carpinus are wind pollinated and produce large quantities of pollen. The rare occurrence of Carpinites in this zone indicates the existence of such plants at a distance. The source of these pollen may be in an elevated area with a cooler climate.

Ilex belonging to family Aquifoliaceae is principally a North American genus. It mostly occurs in woodland flora. Ilexpollenites

may be indicative of woodland vegetation in this zone. Other arboreal elements belong to family Nyssaceae, Proteaceae and Symplocaceae.

A rainforest vegetation, sheltering abundant aquatic ferns and angiosperms growing in marshes, stagnant fresh water ponds, pools, brooks or rivulets is inferred. The deposition of this zone took place under a prevalent humid subtropical climate.

ECOLOGY OF THE PULCHERIPOLLENITES KREMPII ZONE (IV)

Of 95 angiosperm species identified in the P. krempii Zone, 23 species appeared and 18 species are restricted to this zone. Most of the species appeared belong to family Liliaceae, Betulaceae (Alnipollenites), Fagaceae (Faguspollenites), Proteaceae, Rhamnaceae, Sapindaceae and Oleaceae. Many species of Aquilapollenites and Mancicorpus also appeared.

Tropical elements are still dominating in the P. krempii Zone. However, a few more temperate elements have appeared in this zone. Alnipollenites has affinity with Alnus pollen. The rare occurrence of Alnipollenites indicates the presence of such plants in the vicinity of the sedimentation. Alnus is a temperate genus and mostly occupies banks or shores of ponds, streams and marshes which provide more humidity. It grows in cooler and humid areas of the humid subtropical climate also. Rare presence of Fagus type of pollen is interesting in this zone. Fagus is a temperate genus and is represented by only one indigenous species in North America. Fagus trees are entomophilous and do not shed much pollen. However, Fagus pollen are transported to long distances by wind (Wodehouse 1935).

The rich microflora of the P. krempii Zone with dominating

angiosperm species suggests a climax type of vegetation in the area. Most of the angiosperm species recorded belong to families occupying tropical to subtropical areas of modern flora. The appearance of a few temperate elements might be indicative of an increase in humidity. Humidity might have increased by the approaching sea which deposited the Drumheller Member over this zone. Alternatively these elements might have been contributed from far distances where cooler climates prevailed.

A rainforest type of vegetation with paludal undergrowth of aquatic ferns and angiosperms was flourishing. Patches of Taxodium stands on swampy areas were common. A humid subtropical climate was prevailing. Precipitation might have increased due to the approach of the sea which shortly transgressed the area following this zone.

ECOLOGY OF THE MANCICORPUS VANCAMPOI ZONE (V)

Out of 69 angiosperm species recorded, 21 species gradually terminated within the M. vancampoi Zone. 5 species appeared and remained restricted to this zone. A fall in the number of angiosperm species is apparent. The lower half of this zone is represented by the Drumheller marine tongue. Thus the deposition of this zone was influenced by the transgression and regression of the sea in this area. Arenaceous sediments are prevalent in this zone and nonpreservation may be one of the causes for the paucity of microflora.

The planktonic foraminifera Hedbergella sp. is recovered from samples collected from the oyster beds exposed along the Drumheller dinosaur trail. These samples also contain abundant glauconite pellets of various shapes. Rare occurrence of megaspores is also noted.

Microplankton occur only in the lower part of the zone.

The transgression of sea in a wide area might have increased humidity and moderated the temperature. The occurrence of Hedbergella, megaspores of aquatic ferns, glauconite and oysters indicate brackish conditions of sedimentation. The area seems to have been connected to the open sea as well as having fresh-water channels, probably in part suggesting tidal floods. The climate is still essentially humid sub-tropical, a little cooler than the suggested climate of the preceding zone.

ECOLOGY OF THE SCOLLARDIA TRAPAFORMIS ZONE (VI)

About 56 angiosperm elements are recorded from the S. trapaformis Zone; 28 of these elements terminate at this level. Only eight species appeared and six of them remained restricted within the zone. The affinities of the species appearing are not certain. There is a definite increase in the gymnosperm microflora indicative of marshy land and warm climate (Srivastava 1967). The climate in the area was probably changing from humid subtropical to humid continental (warm summer) type (under humid microthermal climates of Trewartha 1954). Cooling may have been introduced due to the withdrawal of the sea and elevation of borderland.

ECOLOGY OF THE AZOLLA AND BALMEISPORITES-BEARING INTERVAL (VII)

Microfloristically this is a depauperate zone. Preservation might be poor due to the increase in bentonitic and arenaceous content of the sediments. However, megaspores of Azolla and Balmeisporites are

encountered frequently. The presence of megaspores of aquatic ferns is indicative of continental deposition. Not enough evidence is available to make a meaningful paleoecological assessment.

ECOLOGY OF THE WODEHOUSEA SPINATA ZONE (VIII)

Only 35 angiosperm species are recorded from the W. spinata Zone. Many angiosperm species terminate at this level. Only six species appeared and remain restricted in this zone. The natural affinities of the species which appear are uncertain. Gymnosperm species dominated over angiosperms. Many species of Azolla flourished during the deposition of this zone. The number of pteridophytes also increased.

Deposition took place in lacustrine conditions. Arboreal vegetation near the deposition was not very rich in variety. It was mixed with various cycads, conifers and angiosperms. A rich groundflora of pteridophytes and aquatic plants was present. A fair amount of the conifer microflora might have been contributed from the upland temperate vegetation on the borderland.

The prevailing climate was humid continental (warm to cool summer) type of the humid microthermal climates (Trewartha 1954). Cooling may have been due to the withdrawal of the sea, uplift of the borderland and the amount of volcanic ash in the atmosphere (Srivastava 1967).

Brayton (1953) analysed the prevailing climatic conditions during the deposition of the Genesee flora on the basis of the structural characteristics of the dicotyledonous fossil leaves as compared with modern leaves against known climatic requirements. The analysis indicated a cool to warm temperate climate during the deposition of

the Genesee flora, like that of southern Ontario. Microfloral analysis of the W. spinata Zone also indicates almost similar conditions with the presence of a few elements suggesting a warmer climate than during the deposition of the Genesee flora.

ECOLOGY OF THE WODEHOUSEA FIMBRIATA ZONE (IX)

This zone is recognised by the appearance of W. fimbriata. The number of angiosperm species further diminishes and gymnosperms increase. The detailed study of this zone is not within the scope of this project. However, the microflora suggests a warm temperate aspect of the climate.

CHAPTER VII - CORRELATION AND AGE

CORRELATION OF MICROFLORAL ASSEMBLAGES OF THE UPPER CRETACEOUS STRATA FROM DIFFERENT PARTS OF THE WORLD

Canada

No microfossil work is available on the Canadian strata isochronous or contemporaneous to the Edmonton Formation. Rouse (1957) described a rich microflora from the Upper Cretaceous Comox Formation of Vancouver Island (Campanian) and the Oldman Formation of southern Alberta (Santonian). None of the angiosperm species described from the Comox Formation is recovered from the Edmonton Formation. A few of the long ranging angiosperm species - Liliacidites variegatus, Cranwellia striata and Trifossapollenites ellipticus - occur in the Oldman Formation as well as in the Edmonton Formation. Trifossapollenites ellipticus ranges from the Aquilapollenites leucocephalus Zone to the Pulcheripollenites krempii Zone in the Edmonton Formation. The representative species of Aquilapollenites, occurring in the Oldman and in the Edmonton Formation are different. Aquilapollenites has not been recorded from the Comox Formation.

United States of America

Stanley (1965) studied the microflora of the Upper Cretaceous and Paleocene strata from northwestern South Dakota, U.S.A. Presence of characteristic species like Wodehousea spinata and Aquilapollenites amplus indicates that the upper Crow Butte Section of the Hell Creek Formation (Zone II and I) can be correlated with the Wodehousea spinata Zone of the Edmonton Formation. Wodehousea fimbriata in the Edmonton

Formation seems to be appearing earlier than its recorded occurrence in the North Cave Hill section representing the Ludlow Member of the Fort Union Formation, South Dakota (Stanley 1965) and Montana (Norton and Hall 1967). W. fimbriata appears above the W. spinata Zone of the Edmonton Formation.

Aquilapollenites reductus and A. conatus have been reported by Norton (1965) from the Hell Creek Formation of Garfield County, Montana. A. reductus is present throughout the Edmonton Formation but A. conatus is restricted within the Wodehousea spinata Zone. The strata containing A. conatus in the Hell Creek Formation of Montana may be correlated with the Wodehousea spinata Zone of the Edmonton Formation.

The upper Moreno Formation at Escarpado Canyon in California is a marine facies of the Late Cretaceous-Paleocene time. Although Proteacidites thalmannii occurs abundantly in the upper Moreno Formation, no specimen of the genus Aquilapollenites has been reported (Drugg 1967). Aquilapollenites is distributed in most Upper Cretaceous continental deposits in the Western Interior of the United States and Canada (Funkhouser 1961; Norton 1965; Norton and Hall 1967; Rouse 1957, 1967; Srivastava 1966, 1967; Stanley 1961, 1965). In Canada, Aquilapollenites has been reported from the Upper Cretaceous sediments on the western side of the Rocky Mountains (Rouse 1967). The shape, structure and wide distribution of Aquilapollenites indicate the anemophilous nature of the pollen which probably could be transported to long distances. Similarly the genus Wodehousea is also absent from the Moreno shale. It may be probable that the Moreno Formation was laid down in a different floral province.

Proteaceae pollen are entomophilous. Proteacidites thalmannii

occurs throughout the Edmonton Formation and in the upper Moreno Formation also (Drugg 1967). Thus the upper Moreno Formation, particularly the Marca Shale, is correlatible to the Wodehousea spinata Zone of the Edmonton Formation. The inferred climatic conditions of these two formations are also similar.

The absence of Aquilapollenites and Wodehousea, and the presence of Proteacidites thalmannii have been noted in the upper Maestrichtian strata of the San Juan Basin, New Mexico also (Anderson 1960).

South America

Maestrichtian microflora reported from South America (van der Hammen 1956a; van der Hammen and Wymstra 1964) does not record any characteristic angiosperm species of the Edmonton Formation.

Africa

Maestrichtian angiosperm microflora described from Africa (van Hoeken-Klinkenberg 1964, 1966; Belsky, Boltenhagen and Potonié 1965; Jardine and Magloire 1965) is essentially different from the microflora of the Edmonton Formation although many angiosperm elements seem to be common. For example, the genus Aquilapollenites is represented in African as well as in Canadian Maestrichtian strata but the species are different in the two regions.

Europe

In general, the microflora of the European strata contemporaneous to the Edmonton Formation has probably not been studied, hence no comparisons

can be made. However, the pollen flora of Mull and Ardnamurchan are believed to have been deposited in the Tertiary Period. According to Simpson (1961) the strata from which the pollen flora has been examined belong to prebasaltic and post-Senonian time. Due to the preponderance of angiosperm pollen in the microflora, Simpson (op. cit.) concluded that these strata belonged to the Tertiary age rather than Cretaceous. Very little palynological data on Upper Cretaceous sediments were available in 1961. Generally, it was believed that prevalence of angiosperms was the character of the Tertiary Period rather than Cretaceous. Genus Aquilapollenites and its various species restricted to the Cretaceous sediments were also not known, although the genus Aquilapollenites had already been diagnosed (Rouse 1957). Obviously, unaware of Aquilapollenites, Simpson (1961) instituted a junior synonym Taurocephalus. He described a heteromorphic species T. proteus suggesting its affinity with Proteaceae pollen. Pollen included in T. proteus belong to Aquilapollenites petasus, A. regalis, A. quadrilobus etc. which are mostly restricted to the lower part of the Edmonton Formation. The pollen flora of Mull and Ardnamurchan could easily belong to the Upper Cretaceous (possibly lower Maestrichtian) pollen flora. The fine preservation of many Aquilapollenites precludes the possibility of contamination of Cretaceous flora into the Tertiary sediments during the volcanic activity in the Tertiary Period. Simpson's (1961) paper was published posthumously.

Aquilapollenites has not been reported from the Cretaceous sediments of Europe. As discussed above its presence in Mull and Ardnamurchan indicates a possibility of finding such pollen in Europe also.

Japan

Aquilapollenites species described by Takahashi from the Upper Cretaceous (Campanian-Maestrichtian) sediments of Japan are similar to those of the lower part of the Edmonton Formation.

U.S.S.R.

The Upper Cretaceous microflora of Siberia has been explored in detail (Bratzeva 1965, 1967; Chlonova 1957, 1960, 1961, 1962; Samoilovitch 1965, 1967; Samoilovitch and Mtchedlishvili 1961). It resembles the flora of the Edmonton Formation. Samoilovitch (1967) recognised two geobotanic provinces on the basis of the angiosperm pollen in the upper Senonian-Danian sediments of Siberia. The microfloral assemblage of the Edmonton Formation is very closely comparable with that of the Yenisey-Amur botanico-geographical province rather than the Khatanga-Lena province. Three subprovinces viz. the Ust-Yenisey subprovince, the Middle Yenisey subprovince and the Baikal-Zeya-Bureya subprovince have been distinguished within the Yenisey-Amur province (Samoilovitch 1967). The microfloral differences in these three subprovinces seem to be due to the age difference among each other within upper Senonian-Danian time. The microflora of the Ust-Yenisey subprovince is not represented in the Edmonton Formation which may be older in age. The microflora of the Middle Yenisey subprovince is comparable with the Wodehousea jacutense and W. gracile Zone of the Edmonton Formation. Various temperate elements enter the microflora above the Pulcheripollenites krempii Zone which have been shown as characteristic elements of the Baikal-Zeya-Bureya subprovince.

AGE

The Edmonton Formation overlies the marine Bearpaw Formation and unconformably underlies the Paskapoo Formation. The occurrence of Acanthoscaphites in the Bearpaw Formation is indicative of its Campanian Age (Russell and Landes 1940). However, the distribution of Acanthoscaphites is restricted to the basal part of the Bearpaw. In the 632 feet thick Manyberries section of the Bearpaw Formation, Russell and Landes (1940) recorded Acanthoscaphites in the basal 185 feet of the strata. The sediments above Acanthoscaphites in the Bearpaw Formation may in part be post-Campanian. Russell (1950) suggested a gradual withdrawal of the Bearpaw sea.

The radiogenic age of the Bearpaw shale at Lethbridge, Alberta, is 75 million years (Folinsbee et al. 1961) which falls into early Maestrichtian Age by the Holmes Time Scale (1960). Nascimbene (1963) determined the age of the regressive upper boundary of the Bearpaw Formation in the western Plains as 68 million years.

The microfloral assemblage of the lower part of the Edmonton Formation conforms with the lower Maestrichtian flora described from Siberia and differs considerably from the pre-Maestrichtian microflora (Samoilovitch and Mtchedlishvili 1961; Samoilovitch 1965, 1967). Thus the base of the Edmonton Formation seems to be well within the Maestrichtian stage.

Russell (1950) considered the Late Paleocene dating of the Paskapoo Formation and the Edmonton-Paskapoo unconformity to belong to Early and Middle Paleocene time. However, Sternberg (1949) located dinosaurian remains at several horizons up to 90 feet above the Ardley coal seam and included the beds immediately above the Ardley coal seam

in the Cretaceous.

On the basis of the vertebrate fauna, the Edmonton Formation above the Kneehills Tuff has been correlated with the Lancian Stage which is believed to represent an upper part of the Maestrichtian (Dorf 1942; Russell 1964; Clemens and Russell 1965). Sternberg (1947) also suggested the Lance age for the upper Edmonton division based on the occurrence of certain dinosaurian fauna (Triceratops) above the Kneehills Tuff.

The Fox Hills fauna corresponds to the upper Maestrichtian fauna of the European sequence (Cobban and Reeside 1952). Westward the marine members of the Fox Hills sandstone pass into the overlying Hell Creek and Lance Formations. At the top of the Cretaceous sequence in the Western Interior of the United States, there are widespread non-marine deposits (e.g. the Hell Creek and Lance Formations) which are particularly characterised by the Triceratopsian dinosaur fauna. Triceratops bones have been located in the mammal-bearing member of the Edmonton Formation also (C. R. Stelck, pers. comm.) indicating its equivalence to the Lancian Stage. Microflora at the top of the Hell Creek Formation in South Dakota (Stanley 1965) and in Montana (Norton and Hall 1967) are characterised by the presence of Wodehousea spinata Stanley. The microflora of the Ludlow member (Paleocene) of the Fort Union Formation in South Dakota (Stanley 1965), and that of the Tullock Formation (Paleocene) in Montana (Norton and Hall 1967) are characterised by Wodehousea fimbriata Stanley. A similar feature has been noted in the Edmonton Formation also. Wodehousea spinata appeared in the Blackmud Member of the Edmonton Formation and occurred through the mammal-bearing member in the upper Edmonton division. W. spinata terminates at the base

of the Nevis Member. W. fimbriata appears above the Nevis coal seam in abundance together with a characteristic microflora conformable with the microfloral zone B of the upper Edmonton division in central Alberta (Snead 1968).

Except for dinosaurian remains found by Sternberg (1949) which he claimed to be located above the Ardley coal seam, all Lancian fauna and flora of the Edmonton Formation belong to its mammal-bearing member. The occurrence of Wodehousea spinata in the angiosperm microflora of the Edmonton Formation correlates its mammal-bearing member with the top of the Hell Creek Formation. The appearance of W. fimbriata above the mammal-bearing member of the Edmonton Formation anticipates the Paleocene aspect of the flora.

The radiogenic ages of the Kneehills Tuff and the Ardley coal seam are 66 million years and 63 million years respectively (Folinsbee et al. 1961). Considering the Holmes Time-Scale (1960), both these ages fall within the Tertiary Period. However, the strata above the Kneehills Tuff containing dinosaurian fauna, i.e. at least up to the Nevis coal seam, should be included in the Cretaceous Period.

Thus the strata of the Edmonton Formation studied and discussed in the present project belong to the uppermost Cretaceous or Maestrichtian Stage.

CHAPTER VIII - SUMMARY AND CONCLUSIONS

The Edmonton Formation is distributed over much of the southern Alberta Plains and is essentially a continental deposit. The main lithologic units are sandstones, shales, ironstones, lignitic shales and coal. Bentonite is present in varying amounts throughout the formation. The Edmonton Formation has been divided into various convenient divisions using the Drumheller marine tongue and Kneehills Tuff as marker horizons. In the present study, the three classical divisions (lower, middle, upper) of the Edmonton Formation as suggested by Allan and Sanderson (1945) are accepted. These divisions have been further subdivided into members. Thus the lower Edmonton division contains four members - a transition member, a coaly member, a non-coaly member, and the Drumheller Member; the middle Edmonton division also contains four members - The Tolman Member, a coaly member, the Whitemud Member, and the Blackmud Member; and the upper Edmonton division contains two members - a mammal bearing-member and the Nevis Member.

No break in the fossil fauna or megaflora (fossil leaves) is observed in the Edmonton Formation until after the deposition of the Kneehills Tuff. The present project was directed toward a study of the angiosperm microflora of the Edmonton Formation to establish microfloral breaks on the basis of the appearance and change of species. Angiosperms went through a rapid evolution in Late Cretaceous Time and many species are restricted within short vertical ranges. The spectrum of the angiosperm microflora of the Edmonton Formation provides the data for calibration and correlation of other equivalent deposits.

On the basis of the appearance of different species at different levels, nine microfloral assemblage zones have been recognised

in about 840 feet of strata of the Edmonton Formation in the Red Deer River Valley of Alberta. The nine zones recognised in the Edmonton Formation are:
(I) The Transition Zone, (II) the Aquilapollenites leucocephalus Zone, (III) the Wodehousea jacutense and W. gracile Zone, (IV) the Pulcheripollenites krempii Zone, (V) the Mancicorpus vancampoi Zone, (VI) the Scollardia trapaformis Zone, (VII) the Azolla and Balmeisporites-bearing Interval, (VIII) the Wodehousea spinata Zone, (IX) the Wodehousea fimbriata Zone.

Contrary to the report of a marked break in the fauna and megaflora at the Kneehills Tuff, angiosperm microflora shows major breaks at the onset of the Drumheller marine tongue, at the base of the Blackmud Member, and at the top of the Nevis coal seam. The angiosperms introduced at the base of the Blackmud Member continued through the Kneehills Tuff.

Three subzones viz. the Mancicorpus borealis Subzone at the base of the Pulcheripollenites krempii Zone, the Mancicorpus gibbus Subzone at the base of the Scollardia trapaformis Zone, and the Polycolpites pocockii Subzone at the top of the Wodehousea spinata Zone, have been recognised. The Mancicorpus gibbus Subzone could be identified in both the Scollard sections and the Cypress Hills section situated about 250 miles apart.

Regression of the Bearpaw sea allowed the onset of brackish deposition of the basal Edmonton Formation. Proximity of the sea provided sufficient humidity and a paludal environment. The vegetation was slowly taking over the areas vacated by the sea. By Pulcheripollenites

krempii time, woodland vegetation had developed toward a climax type. The approaching sea which laid the Drumheller marine tongue on the top of the P. krempii Zone provided sufficient humidity to give enough precipitation to develop rainforest vegetation, fresh water marshes, ponds, brooks and rivulets. Aquatic ferns and angiosperms were abundant in this zone.

With the spread of the Drumheller marine tongue, the angiosperm species diminished in number. Free mixing of marine and fresh water is indicated during the deposition of the Drumheller marine tongue by the presence of Hedbergella sp., Azolla megaspores, glauconite pellets and oyster beds. After the deposition of the Drumheller marine tongue, the sea regressed rapidly. Many more tropical and subtropical angiosperm elements disappeared in this zone. A few temperate and warm temperate elements appeared. The number of gymnosperm and pteridophytic species increased in the Scollardia trapaformis Zone. There was a humid microthermal climate of the humid continental (warm summer) type. Aquatic flora flourished in the paludal environment.

The Blackmud Member, containing the Kneehills Tuff, represents lacustrine deposition. The climate had become cooler and less humid. An increase in the cycadalean flora is indicative of savanna type of vegetation. Conifer pollen might have been contributed from a more distant source with an elevated topography. Various types of aquatic ferns and angiosperms were abundant in the area. An increase in the bentonitic content in the sediments indicates volcanic activity at some distance, contemporaneous with Cordilleran uplift. Volcanic ash fall from the atmosphere might be one of the causes of initiation of cooler temperatures.

At the top of the Blackmud Member, the lacustrine environment changes to a fluvial or flood plain envornment. Mammal and dinosaur remains were deposited in these strata. Essentially the microflora introduced at the base of the Blackmud Member did not change much except that the temperate elements increased. The prevailing humid microthermal climate was of the humid continental (warm to cool summer) type.

The microflora changes to bear a Paleocene aspect above the top of the Nevis coal seam.

Evolution of the angiosperm microflora in the Edmonton Formation started after the regression of the Bearpaw sea. Under the humid subtropical climate, angiosperm flora reached a climax before the transgression of the marine waters which deposited the Drumheller marine tongue. In the Mancicorpus vancampoi Zone of the Edmonton Formation, tropical and subtropical angiosperms diminished in number with the onset of cooling and pteridophytes, gymnosperms and temperate elements of angiosperms increased. During the deposition of the Blackmud Member, a warm temperate climate had been reached. The microflora, appearing at the base of the Blackmud Member, remained essentially the same until the Nevis coal seam was deposited.

The microflora of the Edmonton Formation is comparable with the Maestrichtian microflora described from Siberia. The microfloral assemblage of the Wodehousea spinata Zone of the Edmonton Formation is very similar to the microflora recorded from the top of the Hell Creek Formation of South Dakota and Montana in the United States.

The strata of the Edmonton Formation studied in the present project belonged to the Maestrichtian Stage. The basal part of the Transition Zone of the Edmonton Formation might belong to the uppermost Campanian Stage.

CHAPTER IX - FORMAL TAXONOMIC DESCRIPTIONS

Family LILIACEAE

Genus *Liliacidites* Couper 1953

TYPE SPECIES: *Liliacidites kaitangataensis* Couper 1953.

REMARKS: Couper (1953) proposed the genus *Liliacidites* for the reception of fossil pollen of liliaceous affinities.

Liliaceae are a monocotyledonous family and the largest of flowering plants. They are cosmopolitan in habitat. The smaller groups are often confined to definite floral regions. Herbs, shrubs, xerophytes, succulents, and climbers are represented in the family. Shrubs and trees are very few (Willis 1966).

Liliacidites mirus n. sp.

Plate I, Figures 1-7.

DESCRIPTION: Monosulcate, sulcus long, extending from one longitudinal end to the other, broader at longitudinal ends, narrower in the middle; outline elliptical; sexine about 3.5 microns thick; baculate, punctireticulate; ornamentation reticulate, muri broad, about 2.5 microns wide, muri formed by 3 to 4 rows of baculae which fuse on the surface leaving spaces in between them (punctae), thus muri punctate; lumina large, 1.5 to 3.5 microns size; on the margins of sulcus (distal ? surface) sexine thin, larger reticula grade into very small size, muri low and thin.

SIZE RANGE: Length 36.0 to 60 microns; breadth 32.0 to 38.0 microns.

HOLOTYPE DIMENSIONS: Length 50.4 microns; breadth 36.8 microns.

HOLOTYPE PREPARATION: DH 9/1 : 61.6/112.7, Pl. I, Figs. 1, 2.

ILLUSTRATED SPECIMENS: EC 8/1 : 37/121.3, Pl. I, Fig. 3; DH 4/1 : 50.7/119.9, Pl. I, Fig. 4; DH 33/2 : 59.8/117.8, Pl. I, Fig. 5; Sc 18-26/1 : 46/120.6, Pl. I, Figs. 6, 7.

LOCALITY: Drumheller Locality, Scollard Locality 18, and East Coulee Locality, lower and middle divisions, Edmonton Formation; Maestrichtian.

REMARKS: Liliaceae are a eurypalynous family. The sexine ornamentation of L. mirus is comparable with pollen of certain members of the section Lilioideae (Erdtman 1952). Definite tectate sexine, reticulate ornamentation with thick muri and ornamentation becoming finer on the margins of sulcus are the distinguishing characteristics of L. mirus.

NAME DERIVATION: Latin mirus = wonderful, astonishing.

Liliacidites morrinensis n. sp.

Plate I, Figure 8

DESCRIPTION: Monosulcate, sulcus long, extending from one longitudinal end to the other, width almost equal throughout the length of sulcus, longitudinal ends of sulcus round; outline oval; sexine about 0.8 micron thick, baculate, tectate, reticulate; reticulations large at proximal side becoming smaller towards distal side (at the side of sulcus), distal area around sulcus almost smooth, reticulations become

finer towards the longitudinal ends also, longitudinal ends almost smooth, largest lumina size 2.4 microns, thickness of muri about 0.8 micron.

SIZE RANGE: Length 22 to 26 microns; breadth 20 to 22 microns.

HOLOTYPE DIMENSIONS: Length 24.0 microns; breadth 20.8 microns.

HOLOTYPE PREPARATION: MB 1/1 : 56.8/123.6, Pl. I, Fig. 8.

LOCALITY: Morrin Bridge Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: L. morrinensis can be distinguished by its small size and different ornamentation.

NAME DERIVATION: The specific epithet is derived from the hamlet Morrin near the sample collection locality.

Liliacidites variegatus Couper 1953

Plate I, Figure 9.

1953 Liliacidites variegatus Couper; New Zealand Geol. Surv., Paleont. Bull. 22, p. 56, pl. 7, figs. 98, 99.

SIZE RANGE: Length 26 to 36 microns; breadth 16 to 26 microns.

ILLUSTRATED SPECIMENS: DH 4/1 : 32.8/128.0, Pl. I, Fig. 9.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: The geological range of L. variegatus is from Upper Cretaceous to Lower Oligocene (Couper 1953).

Family ANACARDIACEAE

Genus Rhoipites Wodehouse 1933

TYPE SPECIES: Rhoipites bradleyi Wodehouse 1933.

REMARKS: Wodehouse (1933) compared Rhoipites bradleyi with Rhus pollen, and classified it under the family Anacardiaceae. Family Anacardiaceae is represented in tropical and temperate climates. Rhus is the largest genus of the family and is distributed over tropical and temperate belts of the world.

Rhoipites appears to belong to insect pollinated plants (Wodehouse 1933).

Rhoipites crassus Stanley 1965

Plate II, Figure 1.

1965 Rhoipites crassus Stanley; Bull. Amer. Paleont., vol. 49, no. 222, p. 285, pl. 41, figs. 9-11.

SIZE RANGE: Polar axis 38 to 45 microns; equatorial axis 28 to 34 microns.

ILLUSTRATED SPECIMENS: DH 9/1 : 66.6/121.1, Pl. II, Fig. 1.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Stanley (1965) distinguished various species of the genus Rhoipites Wodehouse on the basis of shape-class-index and size of pollen although they have similar sexine structure.

R. crassus has been recorded from the Paleocene of South Dakota, U.S.A. (Stanley 1965). In Alberta, such pollen have a rare occurrence in the Edmonton Formation (Maestrichtian).

Family BETULACEAE

Genus Alnipollenites Potonié 1931

1931 Alnipollenites Potonié; Jb. Preuss, geol. L.-A., vol. 52, p. 3.

1934 Alnipollenites Potonié, in Potonié; Arb. Inst. Palaeobot., vol. 4, p. 58.

1937 Alnuspollenites Raatz; Abb. Preuss, geol. L.-A. N. F., no. 183, p. 20.

1960 Alnipollenites Potonié, in Potonié; Beih. Geol. Jb., vol. 39, p. 129.

1965 Alnus (Tourn) Hill, in Stanley; Bull. Amer. Paleont., vol. 49, no. 222, p. 287.

TYPE SPECIES: Alnipollenites verus (Potonié) Potonié 1934.

REMARKS: The length of equatorial diameter of recent Alnus pollen is 19 to 22 microns as noted by Wodehouse (1933) and 15 to 20 microns according to Stanley (1965). The length of Alnus quaternaria Stanley is 16 to 24 microns and that of Alnus triana Stanley 13 to 19 microns. The equatorial diameter in Alnipollenites sp. Type A from the Tertiary of Spitsbergen is 30 to 40 microns (Manum 1962). Thus pollen ranging from 15 to 40 microns in diameter have been attributed to the genus Alnus.

Genus Alnipollenites has a rare occurrence in pre-Tertiary horizons. The earliest record of such pollen is from the Turonian-Senonian sequence of Siberia (Chlonova 1960).

Alnipollenites speciipites Wodehouse 1933

Plate II, Figures 2, 3.

1933 Alnipollenites speciipites Wodehouse; Bull. Torrey Botan. Club, vol. 60, p. 508, fig. 40.

SIZE RANGE: Equatorial diameter 20 to 30.4 microns (Wodehouse 1933).

ILLUSTRATED SPECIMENS: Sc 18-13/1 : 46.4/113.0, Pl. II, Fig. 2; Sc 18-13/1 : 41.6/127.0, Pl. II, Fig. 3.

LOCALITY: Scollard Locality 18, middle division, Edmonton Formation; Maestrichtian.

Alnipollenites finitimus (Chlonova) n. comb.

1960 Alnus finitima Chlonova; Trudy Inst. Geol. Geophys., Acad. Nauk SSSR, Novosibrisk, vol. 3, p. 64, pl. 10, figs. 4-6.

1966 Alnipollenites quadrapollenites (Rouse) Srivastava; Pollen et spores, vol. 8, no. 3, p. 530, pl. 7, fig. 3.

DESCRIPTION: 4-5 porate, pores equatorially situated, betuloid in nature; amb four sided in tetraporate pollen and polygonal with rounded angles in pentaporate pollen, sexine about 1 micron thick, tectate, surface smooth, infragranulate, arci present, sexine thickened at pores as in betuloid pollen.

SIZE RANGE: Equatorial diameter 16 to 19.5 microns (Chlonova 1960).

LOCALITY: Scollard Locality 2, upper division, Edmonton Formation; Maestrichtian.

REMARKS: Alnipollenites finitimus (Chlonova) n. comb. has been reported from Turonian-Senonian sequence of Siberia (Chlonova 1960).

Family BUXACEAE

Genus Erdtmanipollis Krutzsch 1962

TYPE SPECIES: Erdtmanipollis pachysandroides Krutzsch 1962.

REMARKS: Krutzsch (1962) designated the form-genus Erdtmanipollis for fossil crotonoid-reticulate polyporate pollen similar to those of Pachysandra and Sarcococca of Buxaceae family. Pollen grains of Pachysandra and Sarcococca are morphologically similar. Their size-range and number of pores intergrade each other. Due to crotonoid ornamentation, it is difficult to count accurate number of pores in such pollen. Size variation and an approximate number of pores can only be used to distinguish different species.

In the diagnosis of the genus Erdtmanipollis, Krutzsch (1962) has noted that pores are present only in 1/3 of the number of lumina. However, a closer examination of such pollen revealed that primarily baculae, of slightly different shapes and sizes, border the rim of every pore, standing out forming somewhat funnel-like structure (crotonoid), rather than pores seated in certain lumina. Being close to each other, these crotonoid structures form a pseudo-reticulate pattern. Thus "lumina without pores" (sensu Krutzsch 1962) are actually mesoporia i.e. spaces between the pores.

Crotonoid-reticulate pollen having affinity with Pachysandra and Sarcococca have been recorded from the Upper Cretaceous to Miocene of U.S.A. (Gray and Sohma 1964; Stanley 1965), Oligocene of Europe (Krutzsch 1962) and from Paleocene to lower Oligocene of Siberia, U.S.S.R. (Samoilovitch and Mtchedlishvili 1961). The fossil record of

such pollen shows the antiquity of the family Buxaceae especially of Pachysandra and Sarcococca.

The family Buxaceae are distributed disjunctly in primarily tropical to subtropical areas. The paleobotanic evidence indicates that the family was once larger and more widely distributed (Gray and Sohma 1964).

Erdtmanipollis albertensis n. sp.

Plate II, Figure 4.

DESCRIPTION: Polyporate, pores about 100 or more, pore rims bordered by baculae in polygonal pattern; amb circular; sexine about 4.0 microns thick, distinctly two layered, foot-layer smooth, about 1.5 microns thick, baculate-layer 2.5 microns thick, bases of baculae fuse and form a hyaline layer of 0.4 micron thick, baculae about 2 to 2.5 microns long, 1.5 microns broad, baculae arranged in polygonal pattern around pore margins, closer at the base opening out like a funnel at their free ends; ornamentation crotonoid-reticulate.

SIZE RANGE: Equatorial diameter 48 to 60 microns (Holotype 52.8 microns).

HOLOTYPE PREPARATION: Sc 18-26/1 : 66/124.8, Pl. II, Fig. 4.

LOCALITY: Scollard Locality 18, middle division, Edmonton Formation; Maestrichtian.

REMARKS: The size range of E. albertensis is larger than E. pachysandroides (25 to 36 microns) and E. procumbentiformis (38 to 44 microns.)

Erdtmanipollis procumbentiformis (Samoilovitch in Samoilovitch and Mtchedlishvili) n. comb.

Plate II, Figures 5, 6.

1961 Pachysandra procumbentiformis Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 199, pl. 64, figs. 1a-d.

1962 Pachysandra cretacea Stanley (pars); Bull. Amer. Paleont., vol. 49, no. 222, p. 294, pl. 44, figs. 6-8.

SIZE RANGE: Equatorial diameter 38 to 44 microns.

ILLUSTRATED SPECIMENS: HC 5/2 : 47.4/125.8, Pl. II, Figs. 5, 6.

LOCALITY: Horseshoe Canyon Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Pachysandra cretacea Stanley has a size range of 20 to 40 microns which overlaps the size ranges of earlier established Erdtmanipollis pachysandroides and E. procumbentiformis.

Family CARPINACEAE

Genus Carpinites Srivastava 1966

TYPE SPECIES: Carpinites ancipites (Wodehouse) Srivastava 1966.

REMARKS: Srivastava (1966) designated form-genus Carpinites to accommodate fossil pollen comparable to those of Carpinus.

Carpinites ancipites (Wodehouse) Srivastava 1966

Plate II, Figures 7, 8.

1933 Carpinus ancipites Wodehouse; Bull. Torrey Botan. Club, vol. 60, p. 510, fig. 42.

1965 Carpinus subtriangula Stanley; Bull. Amer. Paleont., vol. 49, no. 222, p. 291, pl. 43, figs. 12-16.

1966 Carpinites ancipites (Wodehouse) Srivastava; Pollen et Spores, vol. 8, no. 3, p. 530, pl. 7, fig. 1.

SIZE RANGE: Equatorial diameter 25 to 45 microns.

ILLUSTRATED SPECIMENS: DH 9/2 : 45.6/122.1, Pl. II, Fig. 7; Sc 18-26/1 : 46.5/113.6, Pl. II, Fig. 8.

LOCALITY: Drumheller Locality, Scollard Locality 18, lower and middle members, Edmonton Formation; Maestrichtian.

REMARKS: Stanley (1965) described Carpinus subtriangula from the Paleocene of South Dakota which is morphologically similar to C. ancipites Wodehouse from the Eocene Green River Formation of Colorado and Utah. Stanley (1965) did not distinguish the two species. The size range of C. subtriangula Stanley (27 to 33 microns) is well within the size range of C. ancipites Wodehouse (27.4 to 44.5 microns). Hence the two species are treated here as synonyms under the form-genus Carpinites Srivastava 1966.

The rare occurrence of Carpinites ancipites (Wodehouse) Srivastava is recorded from various levels in the Edmonton Formation (Maestrichtian) of Alberta. Its size range is extended here to 25 to 45 microns to accommodate all morphologically similar pollen in one species. The Albertan specimens range in size from 25 to 30 microns only.

Family CHENOPODIACEAE

Genus Polyporina Naumova ex Potonié 1960

TYPE SPECIES: Polyporina multistigmosa (Potonié) Potonié 1960.

DIAGNOSIS: Polyforate, foramina more or less compactly situated, distinctly sunken, double bordered; sexine between foramina more granular than in foramina (Potonié 1960).

REMARKS: Morphological affinity of Polyporina has been suggested with the pollen of Chenopodiaceae which occur widely in the present day flora. Many representatives of the family Chenopodiaceae are wind pollinated. Hence the occurrence of such pollen as fossils have generally been looked upon with doubts. However, frequently such pollen are reported from various horizons of the Tertiary Period (Potonié 1934; Cookson 1953). Potonié (1967) has listed all Tertiary and Quaternary records of such pollen.

Pollen grains of Amaranthaceae, Caryophyllaceae and Phytolaccaceae are very similar to those of Chenopodiaceae (Erdtman 1952; Potonié 1967). The pollen of Chenopodiaceae are indistinguishable from Amararathaceae pollen (Wodehouse 1935).

Double bordered, uniformly distributed foramina with regular margins and a smaller size of pollen distinguish the genus Polyporina from Caryophyllidites Couper 1960.

Polyporina cribraria n. sp.

Plate II, Figures 9, 10.

DESCRIPTION: Polyforate, more than fifty foramina,

uniformly distributed, sunken, bordered rim, diameter of foramina 1.5 to 2 microns; amb circular; sexine thick, tectate, granular between foramina; smooth on rims.

SIZE RANGE: Equatorial diameter 22 to 25 microns (Holotype 24.8 microns).

HOLOTYPE PREPARATION: EC 1/2 : 40.6/115.3, Pl. II, Figs. 9, 10.

LOCALITY: East Coulee Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: P. cribraria can be distinguished from P. multistigmosa in having wider spaces between foramina and smaller size of pollen. P. cribraria has a rare occurrence in the basal Edmonton Formation.

Many plants belonging to the family Chenopodiaceae are characteristic of salt marshes. Erdtman (1943) speculated that the occurrence of chenopodiaceous pollen may be indicative of changes in shoreline. The presence of P. cribraria at the base of the Edmonton Formation is interesting. This was the time of transition from marine conditions of the Bearpaw Formation to the continental Edmonton Formation.

Polyforate pollen have been reported from Maestrichtian of U.S.S.R. also and identified as belonging to the extant genus Altingia (Bratzeva 1965). Pollen of Altingia are larger in size and their foramina are usually of different sizes (Erdtman 1952). Caryophyllidites polyoratus Couper, occurring from Maestrichtian to Danian of New Zealand, is larger in size and has fewer ora (Couper 1960). Morphologically very similar pollen of the extant species

Salicornia australis (Family Chenopodiaceae) is illustrated by Couper (1960). He recovered such pollen from the Tertiary of New Zealand.

NAME DERIVATION: Latin cribraria = sieve like.

Family CORIARIACEAE

Genus Coriaripites n. gen.

TYPE SPECIES: Coriaripites alienus n. sp.

DIAGNOSIS: Tricolpate or tricolporate; pore and colpi breadth coinciding in colporate conditions, colpi small, meridional, aspidate; poles flattened, polar axis compressed, amb broadly triangular with sides convex; sexine very thin; ornamentation obscure, slightly flecked or finely scabrate.

REMARKS: The form-genus Coriaripites is designated here to include pollen having small, aspidate colpi with or without pores. Pores when present are mostly indistinguishable. The morphological features of Coriaripites compare well only with the pollen of the genus Coriaria (family - Coriariaceae) in the modern flora (Cranwell 1942; Erdtman 1952). Coriariaceae pollen have a vague similarity with Corylus (Erdtman 1952). The form-genus Coriaripites superficially resembles the pollen of Corylus, Carpinus, and Carpinites. It can be distinguished in being colpate and having a different mode of sexine at apertures.

Fossil records of such pollen are rare. Zagwijn (1963) reported Coriaria pollen from the Tiglian of the Netherlands. Morphologically similar pollen of Coprosma sp. is illustrated by Cranwell (1964) from the ? Neogene of Rapa Island in the Southern Pacific Ocean.

In the modern flora, family Coriariaceae has only one genus Coriaria, comprised of less than a dozen species of shrubs distributed in the Mediterranean countries, the Himalayan region, Japan, New Zealand and from Mexico to Peru in America.

Pollen grains of Spigelia (Erdtman 1952) have sexine and colpi more or less similar to Coriaripites. The Spigelia pollen have larger size, a different shape, and their apertural area is not aspidate.

Bratzeva (1965) described somewhat similar pollen as Tricolporites gracilis from the Maestrichtian of Far East of U.S.S.R. and compared them with Spigelia pollen.

Coriaripites alienus n. sp.

Plate II, Figure 11.

DESCRIPTION: Tricolpate, colpi short, meridional, aspidate; amb rounded, sides convex with protruding colpi margins; sexine thin, structure obscure, finely scabrate.

SIZE RANGE: Equatorial diameter 25 to 30 microns (Holotype 28.0 microns).

HOLOTYPE PREPARATION: BT 23/1 : 40.2/117.4, Pl. II, Fig. 11.

LOCALITY: Betty Tolman Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Coriaripites alienus differs from Tricolporites gracilis Bratzeva in having circular amb with aspidate colpi and smaller size.

NAME DERIVATION: Latin alienus = strange, foreign.

Family FAGACEAE

Genus Faguspollenites Raatz 1937

TYPE SPECIES: Faguspollenites verus Raatz 1937.

DIAGNOSIS: Tricolporate, spherical to oblately ovoid, angulaperturate, colpi indistinct, margin not thickened, sometimes wrinkled; pores circular; sexine thin, finely infragranulate; infrabaculate, outline somewhat rough, smoother near colpi.

REMARKS: Thinner sexine, circular equatorial pores and indistinct colpi, distinguish the genus Faguspollenites from other similar form-genera.

Faguspollenites granulatus (Martin and Rouse) n. comb.

Plate II, Figures 12, 13.

1966 Fagus granulata Martin and Rouse; Can. J. Botany, vol. 44, p. 199, pl. 9, figs. 93, 94.

DESCRIPTION: Tricolporate, spheroidal, angulaperturate, colpi long, narrow, meridional, reaching polar areas; pores slightly aspidate, vestibulate, with atrium, equatorial, distinct; amb almost circular, sides convex; sexine about 1 micron thick, distinctly double layered, tectate, baculate, scabrate; foot-layer thicker than baculate-layer, both layers distinct; ornamentation microreticulate, lumina about 0.5 micron large, muri low, simplibaculate, about 0.5 micron wide.

SIZE RANGE: Equatorial diameter 20 to 25 microns. Polar

axis 27 to 38 microns; equatorial axis 20 to 30 microns (Martin and Rouse 1966).

ILLUSTRATED SPECIMENS: DH 40/1 : 46.1/119.0, Pl. II, Fig. 12; MB 1/2 : 52/113.0, Pl. II, Fig. 13.

LOCALITY: Morrin Bridge Locality, Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Martin and Rouse (1966) recorded F. granulatus from the late Tertiary shale of Queen Charlotte Islands, British Columbia.

Genus Quercoidites Potonié, Thomson and Thiergart 1950

TYPE SPECIES: Quercoidites henrici (Potonié) Potonié, Thomson and Thiergart 1950.

REMARKS: The distinguishing characteristics of the genus Quercoidites are conical poles of pollen, long colpi, tectate and infrabaculate sexine. Size and the ratio of polar and equatorial axes are diagnostic for different species.

Quercoidites sternbergii Srivastava 1966

Plate II, Figures 14, 15.

1966 Quercoidites sternbergi Srivastava; Pollen et Spores, vol. 8, no. 3, p. 529, pl. 7, figs. 22, 23.

SIZE RANGE: Polar axis 18 to 26 microns; equatorial axis 13 to 18.5 microns; polar axis/equatorial axis ratio 1.3 to 1.4.

ILLUSTRATED SPECIMENS: DH 33/1 : 49.4/121.0, Pl. II, Fig. 14; EC 8/1 : 43.3/126.9, Pl. II, Fig. 15.

LOCALITY: Drumheller Locality, East Coulee Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Subprolate to prolate shape and smaller size of Quercoidites sternbergii distinguish it from other similar species. Affinity of Quercoidites sternbergii are with the extant genus Quercus. Quercus sheds an enormous quantity of pollen which can be transported for long distances.

Family AQUIFOLIACEAE

Genus Ilexpollenites Thiergart 1938

TYPE SPECIES: Ilexpollenites iliacus (Potonié) Thiergart 1938.

REMARKS: Ilexpollenites has morphological affinity with Ilex pollen. Genus Ilex is cosmopolitan in habit.

Ilexpollenites obscuricostatus (Traverse) Srivastava 1966

Plate III, Figure 1.

1955 Ilex obscuricostata Traverse; Rept. Invest. U.S. Bur. Mines, 5151, p. 59, fig. 11 (75).

1966 Ilexpollenites obscuricostata (Traverse) Srivastava; Pollen et Spores, vol. 8, no. 3, p. 533, pl. 7, fig. 14.

SIZE RANGE: Polar axis 35 to 38 microns; equatorial axis 27 to 30 microns.

ILLUSTRATED SPECIMENS: DH 40/2 : 62.8/121.5, Pl. III, Fig. 1.

LOCALITY: Drumheller Locality, lower division, Edmonton

Formation; Maestrichtian.

REMARKS: I. obscuricostatus (Traverse) Srivastava in the Edmonton Formation is the earliest fossil record which has a morphological similarity to Ilex pollen. However, fossil leaves comparable to Ilex are known from Tuscaloosa Formation (Cenomanian-Turonian) of Alabama (Berry 1919).

Family JUGLANDACEAE

Genus Caryapollenites Raatz 1937

TYPE SPECIES: Caryapollenites simplex (Potonié) Raatz 1937.

Caryapollenites paleocenicus (Stanley) n. comb.

Plate III, Figures 2, 3.

1965 Carya paleocenica Stanley; Bull. Amer. Paleont., vol. 49, no. 222, p. 299, pl. 45, figs. 3-7.

SIZE RANGE: Equatorial diameter 20 to 30 microns.

ILLUSTRATED SPECIMENS: DH 36/1 : 67.2/122.4, Pl. III, Fig. 2; DH 36/2 : 50/117.1, Pl. III, Fig. 3.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: C. paleocenicus can be distinguished from various species of Ulmipollenites by having only three pores. Genus Ulmipollenites has more than three pores. The size range of Caryapollenites paleocenicus (Stanley) n. comb. is extended to 20-30 microns from the original size range 22-30 microns (Stanley, 1965) to accommodate morphologically

similar Albertan specimens.

In Alberta, C. paleocenicus has a rare occurrence at lower horizons of the Edmonton Formation.

Family LORANTHACEAE

Genus Cranwellia Srivastava 1966 emend.

1953 Elytranthe striatus Couper; New Zealand Geol. Surv., Paleont. Bull. 22, p. 51, pl. 6, fig. 85.

TYPE SPECIES: Cranwellia striata (Couper) Srivastava 1966.

EMENDED DIAGNOSIS: Isopolar; colpate or colporate pollen, apertures 3 or more than three, angulaperturate, pores conspicuous to inconspicuous, amb triangular with mostly concave or straight and sometimes slightly convex sides, colpi short or long, sometimes reaching the polar area; poles flattened, polar axis compressed, equatorial angular projections well developed making pollen grains a three armed body; sexine tectate, granulate, granules arranged in a linear striate pattern, in polar view striations start from the middle of each mesocolpium and run across to the middle of adjacent mesocolpia, striations parallel to each other and perpendicular to the radius, from pole to the apex of each equatorial projection (i.e. striae circumambulate).

REMARKS: Srivastava (1966) designated the genus Cranwellia to accommodate fossil pollen which show a similarity or affinity with the pollen of the extant genus Elytranthe. Original diagnosis of the genus included only tri- or tetra- colpate and tri- or tetra- colporate

pollen. The genus is here emended to include such pollen also which have more than three apertures in addition to other characteristic morphologic features of Cranwellia.

Cranwellia asperata n. sp.

Plate III, Figure 4.

DESCRIPTION: Tricolpate, angulaperturate, oblate; colpi short, meridional; amb triangular with rounded angles, sides convex; sexine thick, tectate, striate, striae formed by amalgamation of pila, striae margins undulate, undulate margins of adjacent striae close and give an effect of linear pseudoreticulate ornamentation, striae circumambulate, pila heads visible on striae, stria simplipilate.

HOLOTYPE DIMENSIONS: Equatorial diameter 40.0 microns.

HOLOTYPE PREPARATION: DH 10/2 : 44.7/119.1, Pl. III, Fig. 4.

LOCALITY: Drumheller Locality, about 135 feet below the lower oyster bed equivalent, lower division, Edmonton Formation; Maestrichtian.

REMARKS: C. asperata has a larger size and thicker sexine with more compact, conspicuous and different ornamentation compared to C. rumseyensis. C. bacata has concave sides and long colpi in contrast to the convex sides and short colpi of C. asperata. Ornamentation on sexine is also different.

NAME DERIVATION: Latin asperata = rough and irregular.

Cranwellia rumseyensis Srivastava 1966

Plate III, Figure 5.

1961 Elytranthe striatus Couper, in Samoilovitch and Mtchedlishvili (pars), Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 191, pl. 62, fig. 7.

1965 Elytranthe striatus Couper, in Bratzeva (pars); Trans. Acad. Sci. U.S.S.R., Geol. Inst., vol. 129, p. 37, pl. 22, fig. 9.

1966 Cranwellia rumseyensis Srivastava; Pollen et Spores, vol. 8, no. 3, p. 538, pl. 11, figs. 3, 7.

ILLUSTRATED SPECIMENS: EC 8/1 : 46.6/119.2, Pl. III, Fig. 5.

LOCALITY: East Coulee Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Cranwellia rumseyensis has a common occurrence throughout the Edmonton Formation in varying frequencies. This species has been distinguished mainly due to colpate condition rather than colporate condition of C. striata. In the Edmonton Formation C. rumseyensis has dominant presence in comparison to the rare occurrence of C. striata.

Cranwellia bacata n. sp.

Plate III, Figure 6.

1965 Elytranthe sp., in Bratzeva; Trans. Acad. Sci. U.S.S.R., Geol. Inst., vol. 129, pl. 22, fig. 7.

DESCRIPTION: Isopolar; tricolpate, colpi meridional, long reaching polar areas, broad on equatorial area; amb triangular, sides straight or slightly concave; apocolpia small, mesocolpia crescent

shaped with the convex side abutted at poles, mesocolpia look like three segments of an orange arranged with their convex side against each other; sexine tectate, granulate, granules arranged in a linear striate pattern. Striations as described in the generic diagnosis, in the center of mesocolpia striations dupligranulate, near colpi margins simpligranulate.

SIZE RANGE: Equatorial diameter 35 to 45 microns.

HOLOTYPE DIMENSION: Equatorial diameter 40 microns.

HOLOTYPE PREPARATION: DH 33/1 : 52.8/122.9, Pl. III, Fig. 6.

LOCALITY: Drumheller Locality, 210 feet below lower oyster bed equivalent, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Cranwellia bacata has larger granules than other species of Cranwellia. Central striations are dupligranulate rather than simpligranulate. Colpi are long and wedge shaped.

Cranwellia bacata has common occurrence in the Edmonton Formation. Bratzeva (1965) has illustrated a similar specimen from the Maestrichtian of U.S.S.R.

NAME DERIVATION: Latin bacata = set with pearls.

Cranwellia edmontonensis Srivastava 1966

Plate III, Figures 7, 8.

1966 Cranwellia edmontonensis Srivastava; Pollen et Spores, vol. 8, no. 3, p. 538, pl. 11, fig. 9.

SIZE RANGE: Equatorial diameter 30 to 36 microns.

ILLUSTRATED SPECIMENS: Sc 1-24/1 : 48/125.2, Pl. III,

Fig. 7; Sc 1-16/1 : 43.3/125-1, Pl. III, Fig. 8.

LOCALITY: Scollard Locality 1, 42 to 70 feet below Kneehills Tuff, middle division, Edmonton Formation; Maestrichtian.

REMARKS: Cranwellia edmontonensis has rare occurrence in the Edmonton Formation. It is distinguished from other species of Cranwellia in having four colpi.

Cranwellia fida n. sp.

Plate III, Figure 9.

DESCRIPTION: Isopolar, 5-colpate, colpi meridional, long, reaching polar area; amb polygonal, sides concave; sexine tectate, granulose, granules arranged in a linear manner giving striate appearance, striate pattern as described under generic diagnosis.

SIZE RANGE: Equatorial diameter 30 to 38 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 31 microns.

HOLOTYPE PREPARATION: Sc 1-F/1 : 66.2/124.8, Pl. III, Fig. 9.

LOCALITY: Scollard Locality 1, 6 feet above Kneehills Tuff, base of upper division, Edmonton Formation; Maestrichtian.

REMARKS: C. fida can be distinguished from other species of Cranwellia by the presence of five colpi.

NAME DERIVATION: Latin fida = faithful.

Cranwellia striata (Couper) Srivastava 1966

1953 Elytranthe striatus Couper; New Zealand Geol. Surv., Paleont. Bull. 22, p. 51, pl. 6, fig. 85.

1966 Cranwellia striata (Couper) Srivastava; Pollen et Spores, vol. 8, no. 3, p. 537, pl. 11, figs. 1, 4.

REMARKS: The geological occurrence of Cranwellia striata is widespread. It has been recorded from Maestrichtian-Danian of Siberia (Samoilovitch and Mtchedlishvili 1961; Chlonova 1961; Bratzeva 1965), Maestrichtian of Canada (Srivastava 1966), Upper Eocene to Miocene of Australia (Couper 1953, 1960).

In the Edmonton Formation, Cranwellia striata has a rare occurrence.

Genus Loranthacites Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961

TYPE SPECIES: Loranthacites macrosolensides Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961.

DIAGNOSIS: Heteropolar or isopolar, tricolpate, tridiplodemicolpate or tridiplodemicolporate; triangular or triangular with rounded angles; furrows meridional, lanceolate or demicolpate appearing at both sides of the equator and not joining at poles, with or without pores, sexine considerably thick, clavate; ornamentation reticulate or retipilate.

REMARKS: Mtchedlishvili (in Samoilovitch and Mtchedlishvili 1961) noted that Loranthacites is somewhat comparable to Loranthaceae pollen. Modern representatives of Loranthaceae are parasites or semi-parasites with green leaves, distributed in tropical and temperate regions.

Loranthacites pilatus Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961

Plate III, Figures 10, 11.

1961 Loranthacites pilatus Mtchedlishvili in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 195, pl. 63, figs. 1a-c, 2.

DESCRIPTION: Tridiplodemicolporate, angulaperturate, oblate; demicolpi meridional, short, lanceolate, one pore on each demicolpi, pore elongate in equatorial plane; amb triangular with rounded angles, sides slightly concave, poles flattened; sexine at angular regions about 1.6 microns thick, at mesocolpia about 2.4 microns thick, baculate, two layered, foot-layer and baculate-layer, foot-layer as thick as baculate-layer at angles, thickens at mesocolpia, baculae arranged into striate pattern.

SIZE RANGE: Equatorial diameter 30 to 45 microns.

ILLUSTRATED SPECIMENS: HC 4/1 : 64.6/121.5, Pl. III, Fig. 10; BT 18/1 : 67.6/125.5, Pl. III, Fig. 11.

LOCALITY: Horseshoe Canyon, Betty Tolman, lower and middle divisions, Edmonton Formation; Maestrichtian.

REMARKS: Loranthacites pilatus can be distinguished in being tridiplodemicolporate and having pilate sexine. Mtchedlishvili (in Samoilovitch and Mtchedlishvili 1961) has compared the apertures of L. pilatus with pollen of Amylotheca djamuensis (K. Krouse) Denser. However, L. pilatus is demicolporate and A. djamuensis is demicolpate (Erdtman 1952).

Albertan specimens are smaller (31 microns) than the size range of L. pilatus (39.2 to 42.3 microns) given by Mtchedlishvili (in

Samoilovitch and Mtchedlishvili 1961).

Loranthacites catterallii n. sp.

Plate XXXII, Figures 6, 7.

DESCRIPTION: Tridiplodemicolpate, angulaperturate, oblate; demicolpi meridional, long, lanceolate; amb triangular with rounded angles, sides slightly convex; sexine about 1 micron thick, layers not distinct, pilate, pila size less than 1 micron; ornamentation retipilate.

SIZE RANGE: Equatorial diameter 25 to 35 microns.

HOLOTYPE DIMENSION: Equatorial diameter 32 microns.

HOLOTYPE PREPARATION: EC 1A/1 : 34.0/125.2, Pl. XXXII, Fig. 6.

ILLUSTRATED SPECIMENS: EC 2/2 : 57/123.2, Pl. XXXII, Fig. 7.

LOCALITY: East Coulee Locality, base of the Edmonton Formation; Maestrichtian.

REMARKS: L. catterallii can be distinguished from L. pilatus in having thinner sexine and lacking pores. L. catterallii has smaller pila than those of L. pilatus.

NAME DERIVATION: The specific epithet is given after (Miss) Rosalind A. Catterall.

Family MYRICACEAE

Genus Myricipites Wodehouse 1933

TYPE SPECIES: Myricipites dubius Wodehouse 1933.

REMARKS: Wodehouse (1933) compared Myricipites with

Myrica pollen, which had abundant and wide distribution in the Tertiary Period. However, fossil leaves of Myrica have been recorded from the Upper Cretaceous of U.S.A. (Berry 1919).

Myricipites dubius Wodehouse 1933

Plate III, Figure 12.

1933 Myricipites dubius Wodehouse; Bull. Torrey Botan. Club, vol. 60, p. 506, fig. 33.

SIZE RANGE: Equatorial diameter 20 to 26 microns.

ILLUSTRATED SPECIMENS: DH 14/1 : 46.8/114.1, Pl. III, Fig. 12.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: The size of Myricipites dubius was based on a single grain recorded by Wodehouse (1933). Srivastava (1966) recovered many specimens from the Edmonton Formation and gave the size-range from 20 to 26 microns.

Family NYMPHAEACEAE

Genus Zonosulcites Erdtman ex Srivastava

TYPE SPECIES: Zonosulcites scollardensis n. sp.

DIAGNOSIS: Zonosulcate, size variable, sexine retipilate or reticulate.

REMARKS: Erdtman (1947) suggested the name Zonosulcites for the zonosulcate pollen like Nymphaea alba pollen. The form-genus Zonosulcites is here proposed to receive all fossil pollen having zonate

sulcus and reticulate or retipilate sexine.

Zonosulcites scollardensis n. sp.

Plate III, Figure 13.

DESCRIPTION: Monosulcate, sulcus zonate; outline ellipsoidal; sexine thin, surface slightly granulate; ornamentation retipilate, lumina size less than 1 micron.

HOLOTYPE DIMENSIONS: Length 36.8 microns; breadth 24.0 microns.

HOLOTYPE PREPARATION: Sc 1-24/1 : 61.4/112.3, Pl. III, Fig. 13.

LOCALITY: Scollard Locality 1, middle division, Edmonton Formation; Maestrichtian.

REMARKS: Zonosulcites scollardensis is comparable with the pollen of Nymphaea zanzibarensis (Erdtman 1952).

NAME DERIVATION: The specific epithet is after the hamlet Scollard near the sample collection locality.

Zonosulcites parvus n. sp.

Plate III, Figure 14.

DESCRIPTION: Zonosulcate, sulcus around the body, broader at longitudinal ends, narrow at center; shape elliptical; sexine thin, surface smooth, infrareticulate.

HOLOTYPE DIMENSIONS: Length 25.6 microns; breadth 14.4 microns.

HOLOTYPE PREPARATION: DH 33/2 : 34.4/120.9, Pl. III, Fig. 14.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

NAME DERIVATION: Latin parvus = small, little.

Family NYSSACEAE

Genus Nyssapollenites Thiergart 1937

TYPE SPECIES: Nyssapollenites pseudocruciatus Thiergart 1937.

DIAGNOSIS: Tricolporate, suboblate, almost spherical or ovoid; equatorial view sometimes rhombical, amb triangular to rounded triangular; colpi meridional, margins thickened; pores equatorial with thickened margins, sexine infrapunctate.

REMARKS: Potonié (1960) suggested to distinguish European and American species of Nyssapollenites. With description and illustrations available, it seems that American species are larger in size and have conspicuous pores and colpi compared to the European ones.

Family Nyssaceae occupies eastern Asia and eastern North America in the modern flora.

Nyssapollenites parvus n. sp.

Plate III, Figures 15, 16.

DESCRIPTION: Tricolporate, oblate, angulaperturate; colpi size average, narrow, meridional, pores indistinct, equatorial; amb triangular, sides straight; sexine about 0.4 microns thick, tectate surface psilate; ornamentation infrareticulate.

SIZE RANGE: Equatorial diameter 12.0 to 18.0 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 17.6 microns.

HOLOTYPE PREPARATION: DH 35/1 : 35.4/127.8, Pl. III, Fig. 16.

ILLUSTRATED SPECIMENS: DH 4/1 : 55.9/128.2, Pl. III, Fig. 15.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Nyssapollenites parvus is distinguishable from other similar species in having indistinct pores, psilate sexine, and smaller size of pollen.

NAME DERIVATION: Latin parvus = small.

Nyssapollenites bindae n. sp.

Plate III, Figure 17.

DESCRIPTION: Tricolporate, oblately spheroidal, angulaperturate; colpi long, almost reaching poles, tapering, meridional; pores inconspicuous, equatorial margins slightly thicker; amb subtriangular, sides slightly concave; sexine thin, double layered, structure not distinct, scabrate, granules conspicuous in the center of mesocolpia, sexine smooth near colpi.

SIZE RANGE: Equatorial diameter 20 to 25 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 22.4 microns.

HOLOTYPE PREPARATION: DH 35/1 : 28.4/124.9, Pl. III, Fig. 17.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: N. bindae is easily distinguishable from other similar species by smooth sexine near colpi and colpi reaching polar regions.

NAME DERIVATION: The specific epithet is given in honor of Mr. Pier L. Binda.

Genus Nyssoidites Potonié, Thomson and Thiergart 1950

TYPE SPECIES: Nyssoidites rodderensis Thiergart in Potonié, Thomson and Thiergart 1950.

DIAGNOSIS: Tricolporate, spheroidal to compressed ovoid; colpi distinct, meridional; pores larger; amb circular; sexine thick and infratextured.

REMARKS: Nyssoidites is distinguishable from the genus Nyssapollenites Thiergart in having distinct colpi and larger pores.

Nyssoidites edmontonensis n. sp.

Plate IV, Figures 1, 2.

DESCRIPTION: Tricolporate, spheroidal, angulaperturate; colpi size average, meridional, tapering at extremities; pores large, slightly aspidate, equatorial, size 4.8 x 1.6 microns; amb circular, sides convex; sexine about 1 micron thick, tectate, double layered; ornamentation infrareticulate, surface smooth.

HOLOTYPE DIMENSIONS: Polar axis 30.4 microns; equatorial axis 30.4 microns.

HOLOTYPE PREPARATION: EC 7/4 : 46.2/116.9, Pl. IV, Figs. 1, 2.

LOCALITY: East Coulee Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: N. edmontonensis can be distinguished from Nyssoidites ingentipollinus (Traverse) Potonié 1960, in having thinner sexine, shorter colpi and smaller size and from N. rodderensis Thiergart in Potonié, Thomson and Thiergart 1950, in having stronger sexine texture, shorter colpi and spherical shape.

NAME DERIVATION: The specific epithet is after the Edmonton Formation.

Nyssoidites ingentipollinus (Traverse) Potonié 1960

Plate IV, Figure 3.

1955 Nyssa ingentipollinia Traverse; Rept. Invest. U.S. Bur. Mines, 5151, p. 63, figs. 11 (93-97).

1960 Nyssoidites ingentipollinus (Traverse) Potonié; Beih. Geol. Jb., vol. 39, p. 104.

SIZE RANGE: Equatorial diameter 30 to 37 microns.

ILLUSTRATED SPECIMENS: MB 2/1 : 46/120.4, Pl. IV, Fig. 3.

LOCALITY: Morrin Bridge Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: N. ingentipollinus has thick sexine and large pores. Thickenings around pores and colpi are quite distinct in Albertan specimens.

Family OLACACEAE

Genus Anacolosidites Cookson and Pike 1954

TYPE SPECIES: Anacolosidites luteoides Cookson and Pike 1954.

DIAGNOSIS: 6-porate; oblate, angulaperturate; pores round, three on either hemisphere, slightly away from equator, one pore of a hemisphere almost overlies the companian pore of the other hemisphere, thus pores are arranged in three pairs, sexine smooth to varying sculpture.

REMARKS: Pores arranged in pairs, one on either side of equator, on the three angles of the amb, distinguish Anacolosidites from other genera.

Potonié (1960) restricted the genus for smooth to finely sculptured pollen. Probably unaware of Potonié's emendation, Samoilovitch and Mtchedlishvili (1961) described coarsely reticulate Anacolosidites insignis under this genus. Due to lack of sufficient data to erect a new genus on the basis of coarser ornamentation the genus Anacolosidites Cookson and Pike is accepted here as proposed originally.

Anacolosidites insignis Samoilovitch in Mtchedlishvili and Samoilovitch 1960

Plate IV, Figure 4.

1960 Anacolosidites insignis Samoilovitch in Mtchedlishvili and Samoilovitch, VSEGEI, p. 130, figs. 15, 16.

1961 Anacolosidites insignis Samoilovitch in Mtchedlishvili and Samoilovitch, in Samoilovitch and Mtchedlishvili, Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 201, pl. 64, figs. 4a, b, 5, 6a-d.

DESCRIPTION: 6-porate, spherical, angulaperturate, pores in pairs, each pore a little away from equator on each hemisphere, almost overlapping the other pore of the other hemisphere; amb subtriangular, sides convex; sexine 3.2 microns wide, semitectate, three layered, foot-layer and tectate-layer thin, baculate-layer about 1.6 microns thick; ornamentation reticulate, reticulation broken, lumina size 1 to 1.5 microns, muri high, thickness about 1.0 micron.

SIZE RANGE: Equatorial diameter 16.5 to 35 microns.

ILLUSTRATED SPECIMENS: EC 1A/2 : 54.6/119.4, Pl. IV, Fig. 4.

LOCALITY: East Coulee Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Albertan specimens are very similar to Siberian specimens illustrated by Samoilovitch and Mtchedlishvili (1961, pl. 64, figs. 6a-c). A. insignis is reticulate pollen with high muri and easily distinguished from other similar pollen. Albertan specimens are larger than the size-range of A. insignis given by Samoilovitch and Mtchedlishvili (1961). The geological range of A. insignis is from Maestrichtian to Oligocene in Siberia (Samoilovitch and Mtchedlishvili 1961).

Family OLEACEAE

Genus Fraxinoipollenites Potonié 1951

TYPE SPECIES: Fraxinoipollenites pudicus (Potonié) Potonié 1951.

REMARKS: Genus Fraxinoipollenites can be distinguished from Salixipollenites by its fusiform shape and distinctly defined

sexine structure.

Fraxinoipollenites has morphological affinity with Fraxinus pollen. In modern flora Fraxinus is widely distributed in temperate regions of Northern Hemisphere, Cuba and Java.

Fraxinoipollenites variabilis Stanley 1965

Plate IV, Figure 5.

1965 Fraxinoipollenites variabilis Stanley; Bull. Amer. Paleont., vol. 49, p. 306, pl. 45, figs. 29-35.

SIZE RANGE: Polar axis 18 to 25 microns; equatorial axis 15 to 23 microns; shape class index 1.1 to 1.5 (Stanley 1965).

ILLUSTRATED SPECIMENS: DH 9/2 : 26.7/124.2, Pl. IV, Fig. 5.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Fraxinoipollenites variabilis has distinctly clavate sexine.

Family PROTEACEAE

Genus Beaupreaidites Cookson 1950 emend.

1950 Beaupreaidites Cookson; Australian Jour. Sci. Research, Ser. B-Biol. Sci., vol. 3, no. 2, p. 168.

1953 Beaupreaidites Cookson, in Couper; New Zealand Geol. Surv., Paleont. Bull. 22, p. 43.

1960 Beaupreaidites (Cookson) Couper, in Potonié; Beih. Geol. Jb., vol. 39, p. 121.

TYPE SPECIES: Beaupreaidites elegansiformis Cookson 1950.

EMENDED DIAGNOSIS: Pollen grains with three colpoid

apertures, angulaperturate, apertures vestibulate, amb triangular with blunt to rounded angles and ± straight sides, shape oblate; sexine fine to coarsely reticulate, retipilate or verrucate, thinner in apertural areas.

REMARKS: Cookson (1950) diagnosed the genus Beaupreaidites without designating the type species. Beaupreaidites elegansiformis Cookson 1950 was designated as its type species by Couper (1953).

Cookson (1950) emphasised finely reticulate ornamentation as a characteristic feature of Beaupreaidites due to its morphological affinity with Beauprea pollen. Beauprea is the only known genus of family Proteaceae which has tricolpoid pollen.

Unfortunately, detailed morphological features of apertures in the family Proteaceae are not available, although pollen of many extant genera have been studied and described (Wodehouse 1932; Cranwell 1942; Cookson and Erdtman in Erdtman 1952).

Several pollen, recovered from the Upper Cretaceous of Siberia and Alberta, have proteaceous colpoid apertures and sexine structure. Samoilovitch (in Samoilovitch and Mtchedlishvili 1961) described such pollen under the form-genus Proteacidites Cookson ex Couper, 1953. The generic circumscription of Proteacidites includes only orate apertures and not colpoid apertures. Hence these forms cannot be included in Proteacidites. Form-genus Beaupreaidites accommodates colpoid apertures but is circumscribed to include pollen having sexine ornamentation similar to Beauprea pollen.

Both the form-genera - Proteacidites and Beaupreaidites have proteaceous affinity. The proteaceous Upper Cretaceous pollen having colpoid apertures are closer to Beaupreaidites rather than

Proteacidites. The form-genus Beaupreaidites Cookson, 1950, is hereby emended to accommodate colpoid pollen (Fig. 5) with coarser reticulate, retipilate or verrucose sexine also.

Beauprea is restricted to New Caledonia (Australia) in its modern distribution. The abundant presence of Beaupreaidites in Siberia and Alberta, may indicate that the extant genus Beauprea is a relict representative of a flora which produced these pollen and was widespread during the Upper Cretaceous. Proteaceous pollen are entomophilous and not suited for long-distance transportation by wind. Presence of such pollen may indicate the proximity of such flora to the site of deposition.

The following species are here transferred to the genus Beaupreaidites Cookson emend.

Beaupreaidites convexiporus (Samoilovitch in Samoilovitch and Mtchedlishvili) n. comb.

1961 Proteacidites convexiporus Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 172, pl. 52, figs. 2a-c, 3a-c.

Beaupreaidites globosiporus (Samoilovitch in Samoilovitch and Mtchedlishvili) n. comb.

1961 Proteacidites globosiporus Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 173, pl. 53, figs. 1a-g.

Beaupreaidites occulatus (Samoilovitch in Samoilovitch and Mtchedlishvili) n. comb.

1961 Proteacidites occulatus Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 176, pl. 55, figs. 1a-d.

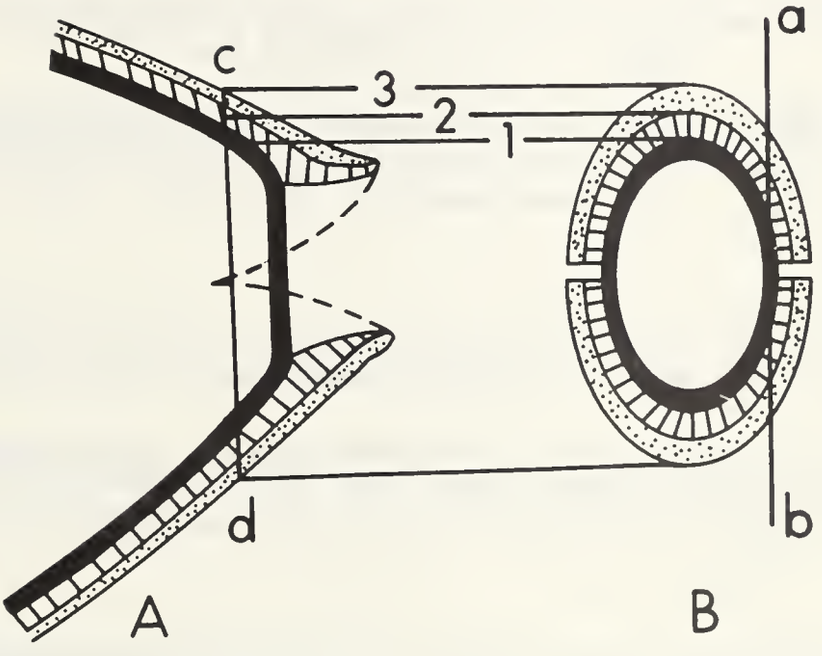

Fig. 5. Diagrammatic sketch showing the structure of apertures in the genus Beaupreaidites Cookson emend.

A: Diagrammatic equatorial section through line a b.

B: Diagrammatic section normal to equatorial plane through line c d.

1-3: Sexine layers 1: foot-layer, 2: baculate layer, 3: outer layer.

Beaupreaidites bellus (Samoilovitch in Samoilovitch and -Mtchedlishvili) n. comb.

1961 Proteacidites bellus Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 178, pl. 55, figs. 3a-d.

Beaupreaidites constrictus (Samoilovitch in Samoilovitch and Mtchedlishvili) n. comb.

1961 Proteacidites constrictus Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 182, pl. 57, figs. 3a-d, 4.

Beaupreaidites mollis (Samoilovitch in Samoilovitch and Mtchedlishvili) n. comb.

1961 Proteacidites mollis Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 185, pl. 59, figs. 1a-d, 2.

Beaupreaidites crispus (Samoilovitch in Samoilovitch and Mtchedlishvili) n. comb.

1961 Proteacidites crispus Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 186, pl. 59, figs. 3a-d.

Beaupreaidites angulatus (Samoilovitch in Samoilovitch and Mtchedlishvili) n. comb.

1961 Proteacidites angulatus Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 187, pl. 60, figs. 1a-c, 2a-d.

Beaupreaidites trilobatus (Samoilovitch in Samoilovitch and Mtchedlishvili) n. comb.

1961 Proteacidites trilobatus Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 190, pl. 61, figs. 4a-d.

Beaupreaidites cerebriformis (Markova) n. comb.

1962 Proteacidites cerebriformis Markova, in Bratzeva, Trans. Acad. Sci. U.S.S.R., Geol. Inst., vol. 129, p. 34, pl. 20, figs. 1, 2.

Beaupreaidites angulatus (Samoilovitch in Samoilovitch and Mtchedlishvili) n. comb.

Plate IV, Figures 6-11; Plate V, Figures 1-5.

1961 Proteacidites angulatus Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 187, pl. 60, figs. 1a-c, 2a-d.

DESCRIPTION: Triaperturate; angulaperturate; apertures large, colpoid; colpi meridional, short, wedge-shaped, extending meridionally beyond apertural zone; amb triangular, sides almost straight, poles flattened, polar axis compressed (oblate); sexine thick, thickness about 3.2 microns, verrucate, three layered, foot-layer smooth, thin, thickness less than 1 micron; bifurcates at the base of apertural zone forming annulus; baculate-layer about 1.5 microns thick, bacula fused forming solid layer, baculae distinguishable by light and dark axes; continuous with same thickness until the extreme end of apertures; third layer thin, verrucate, verrucae irregular, small, low, and close together; ornamentation finely reticulate; lumina arranged in vermiculate pattern due to verrucae studded closely.

SIZE RANGE: Equatorial diameter 50 to 80 microns. Samoilovitch and Mtchedlishvili (1961) gave a size range of 49.1 to 61.7 microns.

ILLUSTRATED SPECIMENS: DH 33/1 : 43.4/112.0, Pl. IV, Figs. 6, 7; DH 7/1 : 61.2/124.7, Pl. IV, Figs. 8, 9; DH 7/1 : 64.6/124.5, Pl. IV, Figs. 10, 11; DH 6/2 : 62.4/116.7, Pl. V, Figs. 1-3;

MB 2/4 : 34.2/122.9, Pl. V, Figs. 4, 5.

LOCALITY: Drumheller Locality, Morrin Bridge Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: B. angulatus has a large size-range. Apertural zones do not bulge or sink. Irregular, low verrucae on sexine are close together forming reticulate ornamentation. Reticula sometimes form vermiculate pattern. The above mentioned characteristics distinguish B. angulatus from other similar species of Beaupreaidites. Sometimes apertures open widely due to distortion of pollen.

Beaupreaidites occulatus (Samoilovitch in Samoilovitch and Mtchedlishvili) n. comb.

Plate V, Figures 6-8.

1961 Proteacidites occulatus Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.- Razv. Inst., Leningrad, vol. 177, p. 176, pl. 55, figs. 1a-d.

DESCRIPTION: Triaperturate, angulaperturate; apertures large, swollen, colpoid; colpi meridional, short, restricted within apertural zones; amb triangular, sides straight, poles flattened, polar axis compressed (oblate); sexine thick, thickness about 3.2 microns, becomes thinner at the base of apertures, giving a swollen appearance to apertures, three layered, foot-layer thin and separates from the other two at the base of apertures; baculate-layer 1.6 microns thick, baculae fused together, upper layer capitate; ornamentation in first focus on surface verrucate, in second focus reticulate, lumina size about 1 micron, muri thickness about 1 micron.

SIZE RANGE: Equatorial diameter 50 to 62 microns. Samoilovitch

and Mtchedlishvili (1961) gave a size-range from 58.8 to 61.2 microns.

ILLUSTRATED SPECIMENS: BT 7/1 : 62.8/126.7, Pl. V, Figs. 6-8.

LOCALITY: Betty Tolman Locality, middle division, Edmonton Formation; Maestrichtian.

REMARKS: Beaupreaidites occulatus is characterised by regular verrucae rather than irregular ones found in B. angulatus. In the second focus, the uniform and distinct reticulate ornamentation distinguishes B. occulatus from B. angulatus which has fine vermiculate reticulation.

Beaupreaidites libitus n. sp.

Plate V, Figure 9; Plate VI, Figures 1-3.

DESCRIPTION: Triaperturate, angulaperturate, apertures colpoid, swollen (tumidus), equatorial; colpi short, meridional, restricted within apertural area; amb triangular, sides convex, constricting at the base of apertures, poles flattened, polar axis compressed (oblate); sexine 3.2 microns thick, verrucate, tapering at apertures; foot-layer separating and forming apertural zones, verrucae become smaller in apertural zones, verrucae height about 1.6 microns, width 1.6 microns; ornamentation verrucate.

SIZE RANGE: Equatorial diameter 35 to 50 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 48.8 microns.

HOLOTYPE PREPARATION: DH 38/2 : 27.7/126.3, Pl. VI, Figs. 1-3.

ILLUSTRATED SPECIMENS: DH 33/2 : 25.7/118.7, Pl. V, Fig. 9.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Large verrucate ornamentation distinguishes B. libitus from other species.

NAME DERIVATION: Latin libitus = pleasing, agreeable.

Genus Proteacidites Cookson ex Couper 1953

TYPE SPECIES: Proteacidites adenanthoides Cookson 1950.

REMARKS: Cookson (1950) described thirteen sporomorphs under the sporotype Proteacidites. Couper (1953) formally diagnosed the form-genus Proteacidites and designated Proteacidites adenanthoides Cookson, 1950, as its type species. Genus Proteacidites has orate apertures which distinguish it from the allied form-genus Beaupreaidites Cookson, 1950, having colpoid porate apertures.

Proteacidites has morphological affinity with Proteaceae pollen. In the modern flora, family Proteaceae is comprised of 1050 species in 62 genera of shrubs and trees distributed in tropical regions of Asia, Malaysia, Australia, New Caledonia, New Zealand; tropical South America, Chile; mountainous tropical Africa, South Africa, and Madagascar. The majority of the representatives are occupying the regions having a long dry season. This shows that most representatives of Proteaceae are xerophytic. However, the primitive members of the family like Helicia etc. are largely rain-forest trees, suggesting that xerophily is probably a secondary nature (Willis 1966). Flowers of modern representatives of family Proteaceae are adapted to entomophilous pollination and cannot be transported for long distances by wind.

Cookson and Erdtman (in Erdtman 1952) gave a morphological account of pollen of many genera belonging to Proteaceae, grouped under Persoonioideae and Grevilleoideae. Pollen of these two sub-families differ in pore and sexine structures. Wodehouse (1932) has also described the pollen of a few genera of the family Proteaceae. However, the detailed apertural morphology has not been given in any of these accounts. The apertural morphology has a great significance in identifying fossil proteaceous pollen.

Although indigenous proteaceous elements are absent in the modern flora of the Northern Hemisphere (except Malaysia), the microfloral studies indicate a world-wide distribution of such a flora during the Upper Cretaceous (Anderson 1960; Bratzeva 1965; Cookson 1950, 1953; Cookson and Pike 1954; Couper 1953, 1960; Drugg 1967; Jardine and Magloire 1965; Samoilovitch and Mtchedlishvili 1961; Srivastava, 1966, 1967; Stanley 1965; van Ameron 1965). The morphological characters of fossil proteaceous flora also show that elements of both Persoonioideae and Grevilleoideae were present in the Northern Hemisphere.

Proteacidites auratus n. sp.

Plate VI, Figure 4.

DESCRIPTION: Triaperturate, apertures large, circular, equatorial, with annulus 5.6 microns wide, aperture diameter 16 to 20 microns at base and 12 to 16 microns at the opening; amb triangular, sides straight to slightly convex, poles flattened; sexine about 2.5 microns thick, distinctly three layered, foot-layer, baculate- and

tectate-layer, pilate, pila heads distinctly visible in the tectate-layer, tectum often broken; ornamentation retipilate, reticulations often broken due to semitectate sexine.

SIZE RANGE: Equatorial diameter 50 to 60 microns.

HOLOTYPE DIMENSION: Equatorial diameter 52 microns.

HOLOTYPE PREPARATION: MB 2/2 : 34.0/119.5, Pl. VI, Fig. 4.

LOCALITY: Morrin Bridge Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: P. auratus is distinguished from other species of Proteacidites due to large size of pollen with large apertures, and pilate, semitectate sexine forming imperfect reticulations.

NAME DERIVATION: Latin auratus = ornamented with gold.

Proteacidites thalmannii Anderson 1960

Plate VI, Figures 5-7.

1960 Proteacidites thalmanni Anderson; State Bur. Mines Miner. Resour., New Mexico, Mem. 6, p. 21, pl. 2, figs. 1-4, pl. 10, figs. 9-13.

1965 Proteacidites retusus Anderson, in Stanley (pars); Bull. Amer. Paleont., vol. 49, no. 222, p. 307, pl. 46, figs. 4, 5 (non figs. 1-3, 6).

1967 Proteacidites thalmanni Anderson, in Drugg; Palaeontographica, vol. 120, pt. B, p. 58, pl. 8, fig. 38.

SIZE RANGE: Equatorial diameter 17 to 41 microns.

ILLUSTRATED SPECIMENS: EC 7/3 : 28.6/124.8, Pl. VI, Fig. 5; DH 4/1 : 28/127.8, Pl. VI, Figs. 6, 7.

LOCALITY: East Coulee Locality, Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Anderson (1960) designated Proteacidites thalmannii from the uppermost Cretaceous of San Juan Basin, New Mexico. P. thalmannii has characteristic protaceous notch-like pores and coarse reticulations. Sise range quoted by Anderson (1960) is 17 to 29 microns. Drugg (1967) recovered P. thalmannii from the Maestrichtian-Danian strata of the Upper Moreno Formation of Escarpado Canyon, California. These forms compare well with the specimens illustrated by Anderson (1960). Drugg (1967) has given the size of P. thalmannii ranging from 22 to 41 microns. The size of P. thalmannii is here extended from 17 to 41 microns. The Albertan specimens measure around 30 microns.

Stanley (1965) identified P. retusus Anderson from the Maestrichtian of South Dakota. Figures 4 and 5 (Stanley 1965, pl. 46) illustrated under the name P. retusus show distinctly coarser reticulations and seem to be morphologically similar to P. thalmannii.

Bratzeva (1965) described P. thalmannii from the Maestrichtian of U.S.S.R. which have striking similarity with the Albertan forms.

Proteacidites tumidiporus var. ecollariatus Samoilovitch in Samoilovitch and Mtchedlishvili 1961

Plate VI, Figures 8, 9.

1961 Proteacidites tumidiporus var. ecollariatus Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 171, pl. 52, figs. 1a, b.

DESCRIPTION: Triaperturate, apertures circular, large, equatorial, aspidate with annulus about 4 microns wide, diameter of apertures 9.6 to 12 microns; amb triangular, sides slightly convex, poles flattened, polar axis compressed; sexine about 1.3 to 1.6

microns thick, distinctly three layered, foot-layer, baculate- and semitectate-layer, pilate, pila heads distinct in tectum; ornamentation retipilate, at places broken reticulations due to intectate sexine, lumina as large as capita, i.e. about 1 micron wide.

SIZE RANGE: Equatorial diameter 30 to 40 microns.

ILLUSTRATED SPECIMENS: DH 10/2 : 32/119.1, Pl. VI, Figs. 8, 9.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: P. tumidiporus var. ecollariatus can be distinguished from P. tumidiporus in outline, size of body and pores, and thinner annulus. The stratigraphic range of P. tumidiporus var. ecollariatus in Siberia is from Maestrichtian tc Danian (Samoilovitch and Mtchedlishvili 1961).

Family RHAMNACEAE

Genus Rhamnacidites Chitaley ex Potonié 1960

TYPE SPECIES: Rhamnacidites brandonensis (Traverse) Potonié 1960.

DIAGNOSIS: Tricolporate, suboblate to subprolate, angul-aperturate; colpi long, reaching polar area, meridional, pores equatorial; amb triangular, sides straight to ± concave or convex, sexine smooth to finely infra-ornamented.

REMARKS: Genus Rhamnacidites is distinguishable from the genus Vitipites (Wodehouse) Potonié 1960, in having protruded apertural area rather than sunken or straight.

Rhamnaceae are a dicotyledonous and cosmopolitan family in present day distribution.

Rhamnacidites minutapollenites (Rouse) n. comb.

Plate VI, Figure 10.

1962 Rhamnus minutapollenites Rouse; Micropaleontology, vol. 8, no. 2, p. 204, pl. 2, figs. 18, 19.

DESCRIPTION: Tricolporate, oblate, angulaperturate; colpi long, reaching polar area, narrow, meridional, tapering toward extremities; pores small, not distinct, equatorial; amb triangular, sides almost straight, slightly concave or convex; sexine thin, two layered, thickness of layeres equal, thinner around pores; surface smooth, ornamentation faintly infrareticulate, mesh size in mesocolpia about 1 micron.

SIZE RANGE: Equatorial diameter 12 to 18 microns.

ILLUSTRATED SPECIMENS: DH 33/2 : 31.2/120.9, Pl. VI, Fig. 10.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Rhamnacidites minutapollenites (Rouse) n. comb. is distinguishable from R. brandonensis (Traverse) Potonié, 1960, in being smaller in size and having smaller pores.

Rouse (1962) recorded R. minutapollenites from the Burrard Formation (Middle or Upper Eocene) of British Columbia, Canada.

Family SAPINDACEAE

Genus Talisiipites Wodehouse 1933

TYPE SPECIES: Talisiipites fischeri Wodehouse 1933.

DIAGNOSIS: Tricolporate, oblate, angulaperturate; colpi long, narrow, meridional; pores aspidate with annulus, equatorial; sexine finely granulate, more pronounced around pores.

REMARKS: Genus Talisiipites can be distinguished from the genus Faguspollenites in having distinct colpi and from the genus Symplocoipollenites in having smaller pores.

The dicotyledonous family Sapindaceae is distributed in tropical and subtropical areas in the present day flora. Five genera are lianes and the rest are erect trees or shrubs.

Talisiipites fischeri Wodehouse 1933

Plate VI, Figure 11.

1933 Talisiipites fischeri Wodehouse, Bull. Torrey Botan. Club, vol. 60, p. 513, fig. 46.

DESCRIPTION: Tricolporate, oblate, angulaperturate; colpi long, meridional, tapering at extremities; pores well developed, equatorial, aspidate with annulus; amb almost circular, sides convex; sexine thin, about 1 micron thick on mesocolpia, about 1.6 microns thick around pores, two layered, granulate; ornamentation scabrate.

SIZE RANGE: Equatorial diameter 24.0 to 28.5 microns.

ILLUSTRATED SPECIMENS: BT 30/1 : 53.5/122.3, Pl. VI, Fig. 11.

LOCALITY: Betty Tolman Locality, lower division, Edmonton

Formation; Maestrichtian.

REMARKS: Wodehouse (1933) recorded Talisiipites fischeri from the Eocene Green River Formation of U.S.A. The Albertan specimens have more convex sides of the amb than those of the Green River Formation.

Family SALICACEAE

Genus Rousea n. gen.

TYPE SPECIES: Rousea subtilis n. sp.

DIAGNOSIS: Tricolpate, angulaperturate; colpi long, reaching polar area; amb subtriangular or rounded, sides convex; sexine thick, reticulate, lumina larger in mesocolpia becoming smaller at colpi margins and apocolpia.

REMARKS: The genus Rousea is distinguishable from the genus Tricolpites Cookson ex Couper emend. Potonié 1960, in having reticulations larger than 1 micron in mesocolpia which become finer at apocolpia and near the margins of colpi. Pollen grains having uniform reticulations larger than one micron should not be included in Rousea.

The generic name is given in honor of Dr. Glenn E. Rouse, University of British Columbia, Vancouver, Canada.

Rousea subtilis n. sp.

Plate VII, Figure 1.

DESCRIPTION: Tricolpate, oblately spheroidal, angulaperturate; colpi long, reaching polar area, meridional; amb subtriangular to rounded, sides convex; sexine about 4 microns thick, tectate, bastionate, two

layered, foot-layer about 1 micron thick; ornamentation reticulate, muri about 3 microns high, about 1 micron thick, simplibaculate, lumina of irregular polygonal shape, large (about 4-5 microns) in mesocolpia, becoming smaller towards colpi margins and apocolpia, smaller (about 1 micron size) in apocolpia and on margins of colpi.

SIZE RANGE: Equatorial diameter 42 to 50 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 44.8 microns.

HOLOTYPE PREPARATION: DH 6/2 : 43/123.2, Pl. VII, Fig. 1.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Rousea subtilis can be distinguished by its large size and large reticulations at mesocolpia which become very small at apocolpia.

NAME DERIVATION: Latin subtilis - finely woven.

Family SIMAROUBACEAE

Genus Ailanthipites Wodehouse 1933

TYPE SPECIES: Ailanthipites berryi Wodehouse 1933.

DIAGNOSIS: Tricolporate, ellipsoidal or ovoid, amb sub-triangular with slightly sunken angles; colpi long, reaching poles, small pores situated equatorially in colpi; sexine thin with fine infratexture, surface almost smooth.

REMARKS: Ailanthipites is distinguishable from Nyssapollenites and Rhoipites in having smaller pores and colpi reaching poles.

Botanical affinity of the genus Ailanthipites is with the family Simaroubaceae - a dicotyledonous family distributed in

tropical and subtropical areas.

Ailanthipites cupidineus n. sp.

Plate VII, Figures 2, 3.

DESCRIPTION: Tricolporate, ellipsoidal, angulaperturate; colpi long, narrow, reaching poles, meridional; pores large, equatorially elongate, length 4 microns, breadth 3.2 microns, aspidate; amb sub-triangular, sides convex; sexine about 1 micron thick, three layered, foot-layer dense, baculate-layer light, tectate-layer dense and scabrate; ornamentation infrareticulate.

HOLOTYPE DIMENSIONS: Polar axis 20.0 microns; equatorial axis 18.4 microns.

HOLOTYPE PREPARATION: DH 10/1 : 45.4/116.2, Pl. VII, Figs. 2, 3.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Ailanthipites cupidineus is distinguishable from A. berryi in being smaller in size and lacking linear arrangement of reticula.

NAME DERIVATION: Latin cupidineus = cupid like.

Ailanthipites potoniei n. sp.

Plate VII, Figure 4.

DESCRIPTION: Tricolporate, prolate spheroidal, angul-aperturate; colpi long, conspicuous, meridional, reaching poles, pores distinct, equatorial; sexine about 1.6 microns thick, double layered,

both layers of equal thickness, tectate, baculate; ornamentation irregularly reticulate; lumina triangular to polygonal, elongate mostly along polar axis, largest lumina about 4 microns, smallest about 1 micron, muri about 0.8 micron high, simplibaculate, about 0.6 micron wide.

SIZE RANGE: Polar axis 25 to 30 microns; equatorial axis 22 to 26 microns.

HOLOTYPE DIMENSIONS: Polar axis 28.0 microns; equatorial axis 24.0 microns.

HOLOTYPE PREPARATION: HC 5/1 : 54.6/125.9, Pl. VII, Fig. 4.

LOCALITY: Horseshoe Canyon Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Ailanthipites potoniei can be distinguished from other similar species by irregular shape and size of lumina.

NAME DERIVATION: The specific epithet is given in honor of Professor Dr. Robert Potonié of Germany.

Family SYMPLOCACEAE

Genus Symplocoipollenites Potonié 1951

TYPE SPECIES: Symplocoipollenites vestibulum Potonié 1951.

DIAGNOSIS: Tricolporate, oblate, angulaperturate; colpi short, pores vestibulate, conspicuous, equatorial; amb triangular, sides concave to slightly convex; sexine granulate to rugulate, outline scabrate.

REMARKS: Genus Symplocoipollenites can easily be distinguished from the form-genus Senipites in being brevicolpate.

Species described under the genus Porocolpopollenites (Pflug)

Thomson and Pflug, 1953, belong to the earlier designated form-genera Symplocoipollenites Potonié 1951, and Symplocospollenites Potonié, Thomson and Thiergart, 1950, hence the genus Porocolpopollenites is a junior synonym.

Symplocoipollenites morrinensis n. sp.

Plate VII, Figure 5.

DESCRIPTION: Tricolporate, oblately spheroidal, angulaperturate; colpi short, barely make exit from atrium, meridional; pores large, vestibulate, with atrium, equatorial; amb subtriangular, sides convex; sexine about 1 micron thick, double layered, tectate, scabrate, foot-layer forms atrium in pores, outer layer thicker than foot-layer; ornamentation faintly reticulate, lumina size about 0.5 micron, muri very low, height less than 0.5 micron, thickness about 0.5 micron.

SIZE RANGE: Equatorial diameter 20 to 28 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 24.0 microns.

HOLOTYPE PREPARATION: MB 6/1 : 47.0/124.8, Pl. VII, Fig. 5.

LOCALITY: Morrin Bridge Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Symplocoipollenites morrinensis can be distinguished from other similar species by scabrate sexine, shorter colpi and convex sides of amb.

NAME DERIVATION: The specific epithet is derived from the hamlet Morrin near the sample collection site.

Family ULMACEAE

Genus Ulmipollenites Wolff 1934 emend.

1960 Ulmoideipites Anderson; State Bur. Mines Miner. Resour., New Mexico, Mem. 6, p. 20.

TYPE SPECIES: Ulmipollenites undulosus Wolff 1934.

REMARKS: Potonié (1960) mentioned that sexine of Ulmipollenites is rugulate. Here the genus Ulmipollenites is emended to contain pollen having slightly undulate to rugulate sexine. Many extant species of family Ulmaceae have a faintly undulating surface also (Erdtman 1952).

The genus Ulmoideipites designated by Anderson (1960) to accommodate certain ulmaceous pollen is a junior synonym to Ulmipollenites Wolff.

Ulmipollenites planeraeformis (Anderson) n. comb.

Plate VII, Figure 6.

1956 Polyporopollenites undulosus Wolff (pars), in Weyland, Pflug and Jähnichen; Palaeontographica, vol. 105, pt. B, pl. 12, fig. 25, form Z.

1960 Ulmoideipites planeraeformis Anderson; State Bur. Mines Miner. Resour., New Mexico, Mem. 6, p. 20, pl. 4, fig. 13.

1961 Planera hebridica Simpson; Trans. Roy. Soc. Edin., vol. 64, no. 16, p. 447, pl. 14, figs. 8, 9.

1965 Ulmoideipites planeraeformis Anderson, in Bratzeva; Trans. Acad. Sci. U.S.S.R. Geol. Inst., vol. 129, p. 31, pl. 16, figs. 1-3, 7, 8.

DESCRIPTION: Isopolar, 5-porate, pores meridional, situated at equator, length almost twice the breadth; amb almost circular, sides

straight to slightly convex; sexine about 1 micron thick, tectate, verrucate, sexine thicker near pores forming annulus.

SIZE RANGE: Equatorial diameter 25 to 30 microns.

ILLUSTRATED SPECIMENS: Sc 2-C/1 : 42.4/123.1, Pl. VII, Fig. 6.

LOCALITY: Scollard Locality 2, upper division, Edmonton Formation; Maestrichtian.

REMARKS: Anderson (1960) described U. planeraeformis from the uppermost Cretaceous (or lowermost Paleocene) of San Juan Basin, New Mexico. Bratzeva (1965) recorded similar pollen from the Maestrichtian of U.S.S.R.

INCERTAE SEDIS

Genus Monosulcites Cookson ex Couper 1953

TYPE SPECIES: Monosulcites minimus Cookson 1947.

REMARKS: Monosulcate pollen occur in Cycads and in several angiosperms. Couper (1953) validly diagnosed and designated the form-genus Monosulcites to include monosulcate pollen of uncertain affinity. This genus accommodates a wide variety of species which might be remotely related. Potonié (1960) expressed the unsuitability of including reticulate and spinate forms in Monosulcites, which do not fit with the smooth sexinous nature of the type-species M. minimus.

Monosulcites drumhellerensis n. sp.

Plate VII, Figure 7.

DESCRIPTION: Monosulcate, sulcus long, extending from one

longitudinal end to the other, broader at longitudinal ends, sexine thin, wrinkled, wrinkles crescentic, thin outgrowths all over the surface.

HOLOTYPE DIMENSIONS: Length 47 microns; breadth 28 microns.

HOLOTYPE PREPARATION: DH 36/2 : 52.2/117.0, Pl. VII, Fig. 7.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Monosulcate pollen with crescentic outgrowths on surface are unusual. Genus Monosulcites Cookson ex Couper 1953, accommodates monosulcate pollen with variable ornamentation. Tentatively Monosulcites drumhellerensis has been described under this genus.

NAME DERIVATION: The specific epithet is after the town Drumheller near the sample collection locality.

Monosulcites echinatus n. sp.

Plate VII, Figure 8.

DESCRIPTION: Monsulcate, sulcus extending from one longitudinal end to the other, width equal throughout the length of sulcus; outline ovate, sexine thin, echinate, spinule bases broad, apices blunt, shape conical.

HOLOTYPE DIMENSIONS: Length 24.8 microns; breadth 20.8 microns.

HOLOTYPE PREPARATION: DH 36/1 : 23.7/122.4, Pl. VII, Fig. 8.

LOCALITY: Drumheller Locality, lower division, Edmonton

Formation; Maestrichtian.

REMARKS: Echinate ornamentation distinguishes M. echinatus from other species of Monosulcites.

NAME DERIVATION: Latin echinatus = with spinules.

Monosulcites gemmatus Couper 1960

Plate VII, Figure 9.

1960 Monosulcites gemmatus Couper; New Zealand Geol. Surv., Palaeont. Bull. 32, p. 69, pl. 12, figs. 19, 20.

DESCRIPTION: Monosulcate, sulcus narrow, extending from one longitudinal end to the other; outline ellipsoidal, sexine gemmate, gemmae close together, diameter about 1.6 microns.

SIZE RANGE: Length 33 to 44 microns; breadth 20 to 33 microns; depth 19 to 30 microns (Couper 1960).

ILLUSTRATED SPECIMENS: Sc 18-26/1 : 37/118.3, Pl. VII, Fig. 9.

LOCALITY: Scollard Locality 18, middle division, Edmonton Formation; Maestrichtian.

REMARKS: Couper (1960) reported the geologic range of M. gemmatus from middle Oligocene to ? Lower Pleistocene. Rare occurrence of these pollen has been recorded in the Edmonton Formation (Maestrichtian) of Alberta also. Gemmae of the Albertan specimens are more densely packed than those described by Couper (1960).

Genus Disulcites Erdtman ex Potonié 1960

TYPE SPECIES: Disculcites kalewensis Potonié 1960.

DIAGNOSIS: Pollen with two sulci which either run parallel or on the equator.

REMARKS: Genus Disculcites is distinguished from Proxapertites van der Hammen in having two sulci rather than one.

Erdtman (1947) suggested the name Disulcites for the sporomorph group having two sulci. Potonié (1960a) diagnosed and validly proposed the genus. He designated Disulcites kalewensis Potonié as its type species.

Disulcites magnus n. sp.

Plate VII, Figures 10, 11.

DESCRIPTION: Disulcate, sulcus at two longitudinal ends, long, broad, tapering toward the center of pollen, pollen elongate, large, sexine about 2.5 to 3 microns thick, spinate, spines with blunt apices, bases broad, sometimes truncated; ornamentation vermiculate.

HOLOTYPE DIMENSIONS: Length 142 microns; breadth 50 microns.

HOLOTYPE PREPARATION: BT 2/1 : 55.7/116.0, Pl. VII, Figs. 10, 11.

LOCALITY: Betty Tolman Locality, middle division, Edmonton Formation; Maestrichtian.

REMARKS: D. magnus occurs rarely in the Edmonton Formation. The stratigraphic importance and phylogenetic affinity of D. magnus are obscure. They may belong to some aquatic plant.

NAME DERIVATION: Latin magnus = great, large.

Genus Nothopollenites n. gen.

TYPE SPECIES: Nothopollenites primus n. sp.

DIAGNOSIS: Tricolpate or tricolporate, angulaperturate, with Y mark at one of the poles or both the poles; amb triangular; sexine granulate to pilate; ornamentation scabrate to reticulate or retipilate.

REMARKS: The form-genus Nothopollenites is proposed here to accommodate fossil tricolpate or tricolporate pollen with Y mark at one or both the poles. Nothopollenites can be distinguished from the genus Triporoletes Mtchedlishvili in Mtchedlishvili and Samoilovitch, 1960, in being tricolpate or tricolporate rather than being triporate.

Y-shaped pseudocolpoid thin walled areas, alternating with colpi and contiguous at the poles occur in Quisqualis indica pollen of family Combretaceae. Similar pollen are found in Cacoucia, Combretum and Terminalia also (Erdtman 1952).

Combretaceae are a dicotyledonous family represented in tropical and subtropical areas of the modern flora.

Nothopollenites primus n. sp.

Plate VII, Figure 12.

DESCRIPTION: Tricolporate, angulaperturate; slightly oblate; colpi long, meridional, almost reaching polar areas, pores equatorial; Y-mark of thinner sexine at one pole, arms of Y mark reaching arcuate sexinal thickenings near mesocolpia margins, thickened sexine at margins of Y mark; amb triangular with rounded angles, straight to convex sides; sexine about 1.6 microns thick, loosely

tectate, elements of tectum i.e. pila distinct, two layers differentiated, foot-layer bifurcates at furrows and forms pore-chambers; ornamentation scabrate.

HOLOTYPE PREPARATION: DH 24/1 : 30.5/122.0, Pl. VII, Fig. 12.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Nothopollenites primus can be distinguished in being tricolporate and having Y mark at one of the poles.

NAME DERIVATION: Latin primus = first.

Genus Trifossapollenites Rouse 1957

TYPE SPECIES: Trifossapollenites ellipticus Rouse 1957.

DIAGNOSIS: Tricolpate, elliptical; furrows usually on one plane, long, reaching polar areas, meridional, two lateral furrows generally shorter than the median one, extremities generally broader and flaring, flaring of extremities generally more pronounced in median furrow; sexine infratextured, surface usually smooth.

REMARKS: Genus Trifossapollenites Rouse is distinguishable from Eucommidites Erdtman emend. Hughes, 1961, in having all three furrows in one plane. The lateral furrows on Trifossapollenites do not join together like those found in Eucommidites.

Genus Trifossapollenites has morphologic similarity with pollen of family Eucommiaceae. The three colpi in Eucommiaceae pollen are not always of the same length (Erdtman 1952). Grains either with one long and two short colpi or one short and two long colpi are met with. However, in Trifossapollenites all three furrows are on one plane

which is probably contrary to the condition met within extant representatives of the family Eucommiaceae.

Trifossapollenites ellipticus Rouse 1957

Plate VIII, Figures 1-3.

1957 Trifossapollenites ellipticus Rouse; Canadian Jour. Bot., vol. 35, p. 372, pl. 3, figs. 65, 66.

DESCRIPTION: Tricolpate, elliptical; furrows long, reaching polar areas, meridional, two lateral furrows shorter than median furrow, extremities of median furrows broad, loop shaped, furrows seem to be in one plane; sexine thin, layers and structure distinguishable; ornamentation faintly infrareticulate.

SIZE RANGE: Polar axis 35 to 44 microns; equatorial axis 22.7 to 30.9 microns.

ILLUSTRATED SPECIMENS: DH 33/1 : 58.4/122.1, Pl. VIII, Fig. 1; DH 33/2 : 33/125.8, Pl. VIII, Fig. 2; DH 33/2 : 23.6/127.2, Pl. VIII, Fig. 3.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Rouse (1957) recorded T. ellipticus from the Oldman Formation, Western Canada, probably belonging to Campanian Age.

Genus Albertipollenites n. gen.

TYPE SPECIES: Albertipollenites rosalindii n. sp.

DIAGNOSIS: Tricolpate, oblate to spheroidal, colpi short or long, meridional; amb triangular to circular, sides straight to

convex; sexine thick, tectate; ornamentation reticulate, reticula of uniform size over all pollen-body; lumina size 1 micron or larger.

REMARKS: Genus Albertipollenites is distinguishable from the genus Tricolpites in having larger reticulate ornamentation (lumina size 1 micron or larger) and from Rousea n. gen. in having uniform size of reticula over all pollen-body.

Albertipollenites rosalindii n. sp.

Plate VIII, Figures 4-7.

DESCRIPTION: Tricolpate, angulaperturate, oblate to spheroidal; colpi long, meridional, wedge shaped in polar view; amb subtriangular, sides convex; sexine 4 microns thick, tectate, baculate, three layered; foot-layer about 1 micron thick, smooth; baculate-layer 2.0 microns thick, baculae long, separated; tectate-layer about 1 micron thick, simplicapitate; ornamentation reticulate, reticula polygonal with distinct and large capita at angles of reticula; lumina size about 2.4 to 4 microns; muri width about 1.6 microns, simplicapitate.

SIZE RANGE: Equatorial diameter 30 to 40 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 39.2 microns.

HOLOTYPE PREPARATION: HC 6/2 : 68.2/109.3, Pl. VIII, Figs. 4, 5.

ILLUSTRATED SPECIMENS: BT 9/1 : 47.2/123.9, Pl. VIII, Figs. 6, 7.

LOCALITY: Horseshoe Canyon Locality, Betty Tolman Locality, lower and middle divisions, Edmonton Formation; Maestrichtian.

REMARKS: A. rosalindii has morphological affinity with

Oleaceae pollen (Erdtman 1952; Erdtman, Berglund and Praglowski 1961).

NAME DERIVATION: The specific epithet is given after (Miss) Rosalind A. Catterall.

Genus Tricolpites Cookson ex Couper emend. Potonié 1960

1964 Retitricolpites van der Hammen ex van der Hammen & Wymstra; Leidse Geol. Meded., vol. 30, p. 234.

TYPE SPECIES: Tricolpites reticulatus Cookson 1947.

REMARKS: Couper (1953) diagnosed the genus Tricolpites and formally designated Tricolpites reticulatus Cookson 1947, as its type species. He included many tricolpate angiosperm pollen with various sexine sculpture in this genus. As the majority of angiosperm pollen are tricolpate, the genus Tricolpites Cookson ex Couper 1953, could virtually accommodate all such pollen and would become meaningless for taxonomic and stratigraphic purposes. Potonié (1960) emended it to include only finely reticulate pollen. However, Belsky, Boltenhagen and Potonié (1965) again emended the generic diagnosis to include pollen with coarser reticulations also. The latter emendation forfeits the useful purpose achieved by the earlier one (Potonié 1960). The generic diagnosis of Tricolpites Cookson ex Couper as emended by Potonié (1960) is accepted here.

Jardine and Magloire (1965) and Boltenhagen (1967) have included various striate, reticulate tricolpate pollen in Tricolpites from the Upper Cretaceous of Gabon (Africa); thus further widening the generic circumscription.

In describing various species of Tricolpites, confusion

has prevailed due to undefined dimensions of "fine reticulations". It is hereby proposed that the size of lumina for the species described under Tricolpites should be restricted to less than one micron. Species having reticula of one micron or larger size should be described elsewhere.

Van der Hammen (1956) created subform-genus Retitricolpites under the form-genus Tricolpites Erdtman, 1947, for reticulate, tricolpate pollen. He designated Tricolpites (Retitricolpites) ornatus as its type species, which is a recent pollen grain of Neea macrophylla Poepp. & Endl. belonging to the family Nyctagynaceae. Due to the recent pollen being its type, Potonié (1960) held the subgenus Retitricolpites van der Hammen 1956, invalid. However, Pierce (1961) raised it to the rank of a form-genus. Van der Hammen and Wymstra (1964) tried to validate the genus by replacing the original type with a fossil pollen Retitricolpites ovalis van der Hammen and Wymstra 1964. Srivastava (1966) proposed that the genus Retitricolpites may be restricted to retipilate, tricolpate pollen. This, however, is not possible, as many species described under this genus including the type species are reticulate with lumina less than one micron in size and thus overlapping the generic characters of Tricolpites. The genus Retitricolpites is not available for fossil pollen and it is invalid. It is rejected here and treated as junior synonym of the genus Tricolpites due to the following reasons:

1. Retitricolpites designated on the recent pollen of Neea macrophylla can only remain at best a sub-genus of the extant genus Neea.

2. Raising it to generic rank, makes it a junior synonym of the extant genus Neea.
3. The type-species of a genus can only be replaced if the original is lost or found wrong. However, in this case, even if the holotype is lost, lectotype should be replaced by the pollen of Neea macrophylla Poepp. & Endl. and not by anything else.

The genus Tricolpites is distinguished from the genus Platanoidites Potonié, Thomson and Thiergart 1953, in lacking genicules on colpi. A careful description of species under this genus is necessary. A pollen having slight morphological variation may be of different stock.

Many species of Tricolpites have a close resemblance with many genera of the family Hamamelidaceae, chiefly, Corylopsis, Hamamelis and Fothergilla, Family Hamamelidaceae are dicotyledonous and chiefly distributed in subtropical areas of modern climate.

Tricolpites microreticulatus Belsky, Boltenhagen and Potonié 1965

Plate VIII, Figures 8, 9.

1965 Tricolpites microreticulatus Belsky, Boltenhagen and Potonié; Paläont. Z., vol. 39, nos. 1 and 2, p. 75, pl. 12, figs. 8, 9.

DESCRIPTION: Tricolpate, oblate, angulaperturate; colpi about 16 to 20 microns long, meridional, narrow, tapering at ends; amb subcircular, sides convex, apocolpia about 5 microns wide, mesocolpia 14 to 18 microns wide; sexine about 0.8 micron thick, two layered, tectate, infragranulate, granules about 0.4 micron high, 0.4 micron wide; ornamentation reticulate, muri simpligranulate, low, muri thicker than lumina size, lumina size about 0.4 to 0.5 micron.

SIZE RANGE: Equatorial diameter 20 to 28 microns.

ILLUSTRATED SPECIMENS: DH 33/1 : 48.1/124.1, Pl. VIII, Fig. 8; DH 33/2 : 47.9/114.2, Pl. VIII, Fig. 9.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Tricolpites microreticulatus can be distinguished by distinct large apocolpia which are almost lacking in T. clarensis (Guzman) n. comb.

Tricolpites mtchedlishviliae (Lubomirova) n. comb.

Plate VIII, Figure 10.

1964 Corylopsis mtchedlishviliae Lubomirova; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 239, p. 203, pl. 3, figs. 10, 11.

DESCRIPTION: Tricolpate, oblately spherical, angulaperturate; colpi long, almost reaching poles, meridional, tapering at the ends; amb almost circular, sides convex; sexine about 1.5 microns thick, layers indistinct; ornamentation reticulate, lumina about 1 micron, some smaller and a few larger, irregular, muri simplibaculate, high, thickness about 0.8 micron.

SIZE RANGE: Equatorial diameter 25 to 32 microns.

ILLUSTRATED SPECIMENS: DH 36/1 : 26.3/109.8, Pl. VIII, Fig. 10.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: T. mtchedlishviliae (Lubomirova) n. comb. can be distinguished from other similar species in having thicker sexine,

larger and sometimes irregular reticula, and longer colpi.

The geological range of T. mtchedlishviliae is from Maestrichtian to Oligocene. It has similarity with Corylopsis pollen particularly to C. gotoana and C. spicata (Lubomirova 1964).

Tricolpites occidentalis n. sp.

Plate VIII, Figure 11.

DESCRIPTION: Tricolpate, oblately spheroidal, angulaperturate; colpi medium sized, meridional; amb circular, sides convex; sexine about 1.6 microns thick, clearly two layered, inner-layer about 0.8 micron thick; smooth, outer-layer baculate, tectate, about 0.8 micron thick, baculae distinct; ornamentation reticulate, muri high, simplibaculate, thickness about 0.8 micron, lumina size less than 1 micron.

HOLOTYPE DIMENSIONS: Equatorial diameter 23 microns.

HOLOTYPE PREPARATION: DH 36/1 : 46.1/124.0, Pl. VIII, Fig. 11.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: T. occidentalis has a distinct inner layer and a baculate layer. It can be distinguished from other species in having shorter colpi and more distinct elements forming reticulate sexine.

NAME DERIVATION: Latin occidentalis = west.

Tricolpites vulgaris (Pierce) n. comb.

Plate VIII, Figures 12-15.

1961 Retitricolpites vulgaris Pierce; Univ. Minn., Minn. Geol. Surv., Bull. 42, p. 50, pl. 3, figs. 101, 102.

1967 Retitricolpites vulgaris Pierce, in Norris; Palaeontographica, vol. 120, pt. B, p. 108, pl. 17, figs. 20-24.

SIZE RANGE: Equatorial diameter 17 to 37.6 microns.

ILLUSTRATED SPECIMENS: BT 19/1 : 59.8/114.1, Pl. VIII, Fig. 12; DH 35/1 : 55.3/120.2, Pl. VIII, Fig. 13; BT 4/1 : 30.8/124.8, Pl. VIII, Fig. 14; DH 39/1 : 63.8/118.1, Pl. VIII, Fig. 15.

LOCALITY: Drumheller Locality, lower and middle divisions, Edmonton Formation; Maestrichtian.

REMARKS: Albertan specimens of Tricolpites vulgaris are larger in size than those recorded from (?) Cenomanian deposits of Minnesota (Pierce 1961) and from the lower Colorado Group (Albian - ? Cenomanian) of central Alberta (Norris 1967). T. vulgaris has smaller reticula than those of Hamamelis scotica Simpson 1961, and Corylopsis princeps Lubomirova 1964.

Tricolpites vulgaris has morphological affinity with Corylopsis and Hamamelis pollen.

Genus Margocolporites Ramanujam 1966

1966 Margocolporites Ramanujam; Pollen et Spores, vol. 8, no. 1, p. 173.

TYPE SPECIES: Margocolporites tsukadai Ramanujam 1966.

REMARKS: Genus Margocolporites is distinguishable by the presence of margo around colpi.

Margocolporites taylorii n. sp.

Plate IX, Figures 1, 2.

DESCRIPTION: Tricolporate, suboblate, angulaperturate; colpi narrow, size average, tapering, meridional, with broad tapering margo, pores large, equatorial; margo finely granulate; amb subtriangular, sides convex; sexine thickness about 1.6 microns, tectate, three layered; ornamentation reticulate, lumina size about 1 micron, shape irregular; muri thickness about 1 micron, simplibaculate, height about 0.8 micron.

SIZE RANGE: Equatorial diameter 25.0 to 30.0 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 26.4 microns.

HOLOTYPE PREPARATION: DH 38/1 : 48.4/125.7, Pl. IX, Figs. 1, 2.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: M. taylorii can be distinguished from similar species by its small reticulate ornamentation and small size of pollen.

NAME DERIVATION: The specific epithet is given in honor of Mr. Donald A. Taylor, former Museum Curator, Department of Geology, University of Alberta, Edmonton.

Genus Stelckia n. gen.

TYPE SPECIES: Stelckia vera n. sp.

DIAGNOSIS: Tetracolpate, colpi meridional, medium sized, various types of syncolpate conditions present (Fig. 6); amb circular, isopolar, symmetry of pollen grains is not at polar axis but about 30° off the polar axis, oblate; sexine tectate, scabrate.

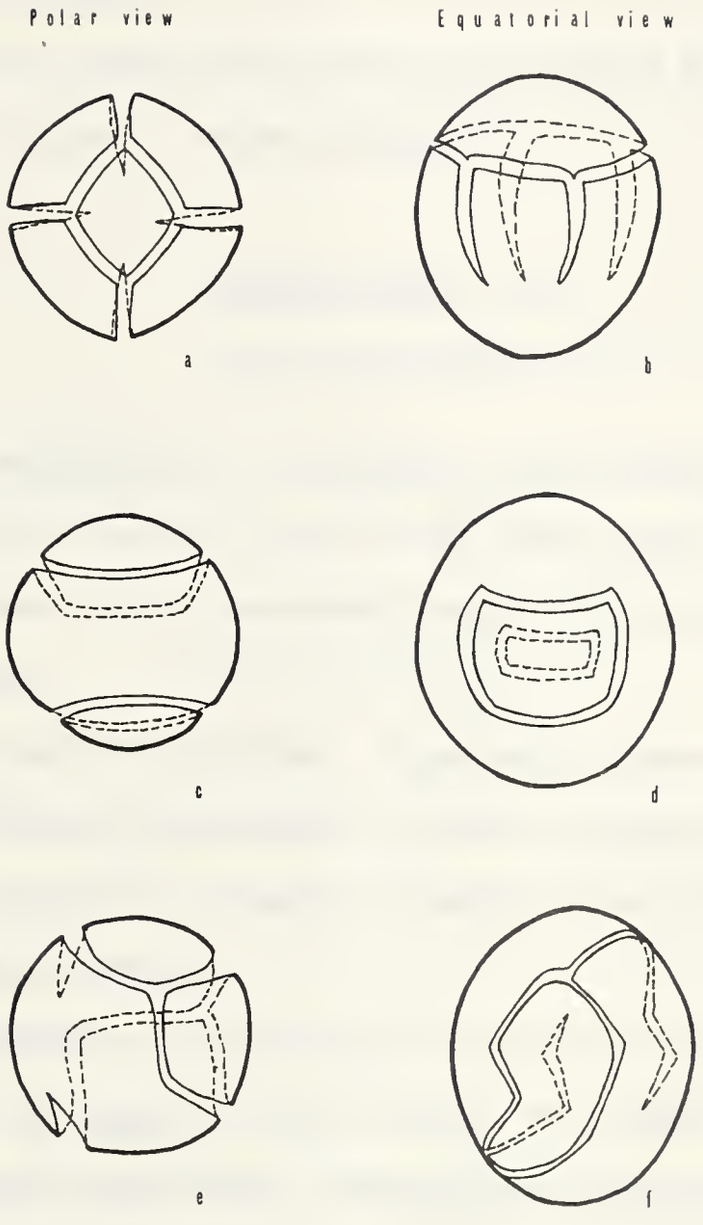

Fig. 6. Diagrammatic sketches of three species of the genus Stelckia showing colpi pattern. a, b: Stelckia vera n. sp.; c, d: S. unica n. sp.; e, f: S. xenoforma n. sp.

REMARKS: Stelckia does not show normal positions of colpi or syncolpate character. Bilateral symmetry of pollen along polar axis is at 30° between the polar and equatorial axis. Botanical affinities are uncertain. Similar colpi behaviour is seen in extant genera of family Berberidaceae.

The generic name is given in honor of Professor C. R. Stelck, University of Alberta, Edmonton (Canada).

Stelckia vera n. sp.

Plate IX, Figure 3.

DESCRIPTION: Tetracolpate, colpi meridional, medium sized, parasyncolpate at one pole, free at the other pole; amb almost circular; polar axis short, poles compressed; sexine tectate, about 1.6 microns thick, scabrate.

HOLOTYPE DIMENSIONS: Equatorial diameter 25.6 microns.

HOLOTYPE PREPARATION: DH 36/2 : 65/121.5, Pl. IX, Fig. 3.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Parasyncolpate condition at only one pole, distinguishes S. vera from other species of the genus Stelckia (Fig. 5a, b).

NAME DERIVATION: Latin vera = real, true, genuine.

Stelckia unica n. sp.

Plate IX, Figure 4.

DESCRIPTION: Tetracolpate, colpi meridional, short, colpi united in pairs by transverse furrows parallel to equatorial axis, thus

encircling quadrangular areas of pollen grain in equatorial view, the quadrangle formed by one of the pairs of colpi always larger than the other; amb almost circular, polar axis short, poles compressed; sexine tectate, about 1.5 microns thick, scabrate.

HOLOTYPE DIMENSIONS: Equatorial diameter 27.2 microns.

HOLOTYPE PREPARATION: DH 36/1 : 36.4/118.2, Pl. IX, Fig. 4.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Colpi joining in pairs and encircling unequal quadrangular areas of pollen distinguish S. unica from other species of the genus Stelckia (Fig. 5c, d).

NAME DERIVATION: Latin unica = only, one.

Stelckia xenoforma n. sp.

Plate IX, Figure 5.

DESCRIPTION: Tetracolpate, colpi meridional, medium sized, three of the four colpi unite on either polar region leaving the end of the fourth colpi free, the colpus free at one pole remains united on the other, no colpus is free at both poles; amb circular, polar axis short, poles compressed; sexine tectate, 1.5 microns thick, scabrate.

HOLOTYPE DIMENSIONS: Equatorial diameter 30.4 microns.

HOLOTYPE PREPARATION: DH 36/2 : 40.8/115.8, Pl. IX, Fig. 5.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Three of the four colpi meeting on either pole with one end of a colpus free is the distinguishing character of

S. xenoforma (Fig. 5e, f). It has stronger scabrate sexine and bigger size than S. vera and S. unica.

NAME DERIVATION: Latin xenoforma = strange form.

Genus Tubulifloridites Cookson 1947

TYPE SPECIES: Tubulifloridites antipodica Cookson 1947.

DIAGNOSIS: Tricolpate, spheroidal, angulaperturate; colpi broad, tapering; pores not observed; amb subtriangular to circular; sexine thick covered with strong spines, spine bases broad, acuminate.

REMARKS: Tubulifloridites is distinguishable from the genus Compositoipollenites in having distinctly visible colpi and lacking pores.

Tubulifloridites aedicula n. sp.

Plate IX, Figure 6.

DESCRIPTION: Tricolpate, oblately spheroidal, angulaperturate; colpi short, meridional, tapering at the extremities; amb almost circular, sides convex; sexine echinate, spinules acuminate and broad at base, about 1.6 microns high.

HOLOTYPE DIMENSION: Equatorial diameter 22.4 microns.

HOLOTYPE PREPARATION: DH 40/1 : 65.8/129.1, Pl. IX, Fig. 6.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: T. aedicula has smaller spinules and smaller size than T. antipodica Cookson 1947.

NAME DERIVATION: Latin aedicula = a small temple. The

epithet is in reference to the "Little Church" of Drumheller near the sample collection locality.

Genus Grewipollenites n. gen.

TYPE SPECIES: Grewipollenites canadensis n. sp.

DIAGNOSIS: Tricolpate, angulaperturate, oblate, colpi long or short, meridional; amb triangularly rounded, sides convex; sexine clavate, striate, striae dispersed radially from a few centers.

REMARKS: Grewipollenites is distinguishable from Callistopollenites and Pulcheripollenites in lacking pores and having only colpi.

NAME DERIVATION: The generic name is given in honor of Nehemiah Grew, one of the founders of microscopic plant anatomy.

Grewipollenites canadensis n. sp.

Plate IX, Figure 7.

DESCRIPTION: Tricolpate, angulaperturate, oblate, colpi long, meridional; amb triangularly rounded, sides convex; sexine thick, tectate, striate, striae dispersed radially from a few centers.

SIZE RANGE: Equatorial diameter 25 to 30 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 27.2 microns.

HOLOTYPE PREPARATION: DH 36/1 : 43.9/127.2, Pl. IX, Fig. 7.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: G. canadensis is the only species described under

the genus Grewipollenites.

Genus Pulcheripollenites n. gen.

TYPE SPECIES: Pulcheripollenites narcissus n. sp.

DIAGNOSIS: Tricolpate, angulaperturate, oblate, colpi very short (brevicolpate), meridional, restricted within thickened angular areas; amb triangular with rounded angles, sides straight to slightly convex; sexine thick tectate striate or reticulate, ornamentation always arranged with striate pattern, circumambient to the angles in polar view.

REMARKS: Pulcheripollenites is distinguishable from Callistopollenites in being brevicolpate and lacking radially dispersed striations from a few centers on pollen. It is distinguished from Beaupreaidites in having thickened zones on the angles of amb and striate reticulations circumambient to the angles in polar view. Genus Striatriporites is porate and has an unsculptured area around each pore.

NAME DERIVATION: Latin pulcher = beautiful.

Pulcheripollenites narcissus n. sp.

Plate IX, Figures 8-10.

DESCRIPTION: Tricolpate, angulaperturate, oblate; colpi short, meridional, restricted within thickened zones on angles of amb; amb triangular with rounded angles, sides slightly convex; sexine 2.4 microns thick, three layered, foot-layer thick, homogenous, about 1 micron thick, baculate-layer joined together, thin, tectate-layer forming striations, about 1 micron thick; striation about 1 micron wide,

undulate, circumambient to angles of amb, at polar areas striations meet each other and form pseudoreticulate pattern, angular areas thickened by foot-layer.

SIZE RANGE: Equatorial diameter 55 to 63 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 60.0 microns.

HOLOTYPE PREPARATION: DH 3/1 : 51.8/121.5, Pl. IX, Figs. 8-10.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: P. narcissus is distinguishable in being larger in size and having coarser sexine elements than P. krempii.

NAME DERIVATION: Narcissus = a Greek mythological character who fell in love with his reflection in a spring.

Pulcheripollenites inrasus n. sp.

Plate IX, Figure 11.

DESCRIPTION: Tricolpoid; angulaperturate, slightly oblate; colpi very short - almost like elongated pores, meridional, restricted within thickened angular areas; amb almost round, sides convex; sexine about 1.6 microns thick, tectate striate, striae thin, close circumambient to equatorial apertures.

SIZE RANGE: Equatorial diameter 30 to 35 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 34.4 microns.

HOLOTYPE PREPARATION: DH 4/1 : 43.3/119.8, Pl. IX, Fig. 11.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: P. inrasus is distinguishable from P. narcissus and P. krempii in having thin, closely spaced striations, very small apertures and more rounded amb. P. inrasus differs from Striatriporites nigeriensis van Hoeken-Klinkenberg in lacking unsculptured area around pores and protruding pore borders.

NAME DERIVATION: Latin inrasus = unshaved.

Pulcheripollenites krempii n. sp.

Plate X, Figures 1-4.

DESCRIPTION: Tricolpate, angulaperturate, oblate; colpi short (brevicolpate), meridional, restricted within thickened zones on angles of amb; amb triangular with rounded angles; sides convex; sexine 1.8 microns thick, other details of sexine similar as in P. narcissus but elements are smaller.

SIZE RANGE: Equatorial diameter 35 to 42 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 40 microns.

HOLOTYPE PREPARATION: DH 4/1 : 63.5/115.2, Pl. X, Figs. 1, 2.

ILLUSTRATED SPECIMENS: DH 2/1 : 50/118.2, Pl. X, Fig. 3; DH 20/1 : 53.2/119.8, Pl. X, Fig. 4.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: P. krempii is distinguishable from P. narcissus being smaller in size and in having pseudoreticulations less than half of the average diameter of those in the latter.

NAME DERIVATION: The specific epithet is named in honor of Dr. G. O. W. Kremp.

Genus Scollardia Srivastava emend.

1966 Scollardia Srivastava; Pollen et Spores, vol. 8, no. 3, p. 544.

TYPE SPECIES: Scollardia trapaformis Srivastava 1966.

EMENDED DIAGNOSIS: Isopolar, tricolpate, colpi long or short, meridional across apices of equatorial projections; equatorial contour triangular; polar projections not developed, equatorial projections well developed, tips of equatorial projections conical, rounded or hook-shaped; sexinal outgrowth on both the margins of colpi developed, sexinal outgrowth may be a thick or membranous frilly outgrowth, sides concave; sexine scabrate, ornamentation striate.

SIZE RANGE: Equatorial diameter 30 to 45 microns.

REMARKS: A closer examination of species described under the genus Scollardia Srivastava revealed that these pollen are tricolpate and not tridemicolpate (sensu Erdtman 1952). The sexinal outgrowth on the apical region of the equatorial projections is on both the margins of colpi. Thus sexinal outgrowth may be thick or membranous and frilly. Various modes of sexinal outgrowths determine the shape of apical region of equatorial projections.

The genus Scollardia can be distinguished from Aquilapollenites by the absence of polar projections, and from Cranwellia by the presence of sexinal outgrowth on the margins of colpi. Translucentipollis Chlonova, 1961, and Accuratipollis Chlonova, 1961 have polar projections.

Scollardia trapaformis Srivastava 1966

Plate X, Figures 5, 6.

1966 Scollardia trapaformis Srivastava; Pollen et Spores, vol. 8, no. 3, p. 544, pl. 10, figs. 11, 12.

REVISED DESCRIPTION: Isopolar; tricolpate, colpi short, meridional across the apices of the equatorial projections; sexine on the margins of colpi thickened; equatorial contour triangular, sides concave; polar projections absent; equatorial projections well developed, tips of equatorial projections twisted and pointed; sexine tectate, baculate; ornamentation striate, striations starting from the middle of mesocolpium and running across to the middle of adjacent mesocolpia; striations parallel to each other and perpendicular to radius, from pole to apex of each equatorial projection.

SIZE RANGE: Equatorial diameter 30 to 40 microns.

ILLUSTRATED SPECIMENS: Sc 1-24/1 : 15.7/111.3, Pl. X, Fig. 5; Sc 1-24/1 : 38.7/121.2, Pl. X, Fig. 6.

LOCALITY: Scollard Locality 1, middle division, Edmonton Formation; Maestrichtian.

REMARKS: In the light of detailed study of the genus Scollardia Srivastava, the revised description of S. trapaformis is given here. S. trapaformis can be distinguished from the other species of Scollardia in having thickened sexinal outgrowths on colpi margins and twisted apical regions of equatorial projections.

Scollardia steevesii Srivastava 1966

Plate X, Figures 7, 8.

1966 Scollardia steevesi Srivastava; Pollen et Spores, vol. 8, no. 3, pl. 10, figs. 4, 5, 7.

ILLUSTRATED SPECIMENS: Sc 1-24/1 : 48.4/110.0, Pl. X, Fig. 7; Sc 18-20/1 : 52.4/123.1, Pl. X, Fig. 8.

LOCALITY: Scollard Locality 1 and 18, middle division, Edmonton Formation; Maestrichtian.

REMARKS: S. steevesii has membranous, frilly sexinal outgrowths on the margins of colpi, which distinguishes it from other species of the genus Scollardia.

Scollardia nortonii Srivastava 1966

Plate XI, Figures 1, 2.

1966 Scollardia nortoni Srivastava; Pollen et Spores, vol. 8, no. 3, p. 545, pl. 10, figs. 1, 6, 8-10, 13, 14.

ILLUSTRATED SPECIMENS: Sc 18-20/1 : 43.8/115.0, Pl. XI, Fig. 1; Sc 1-24/1 : 43.2/127.6, Pl. XI, Fig. 2.

LOCALITY: S. nortonii has very small meridional colpi (brevicolpate) at the distal ends of equatorial projections and not demicolpi as noted by Srivastava (1966). S. nortonii is distinguished from S. steevesii in having smaller colpi, and from S. trapaformis in having membranous sexinal outgrowths at the margins of colpi.

Genus Senipites n. gen.

TYPE SPECIES: Senipites drumhellerensis n.sp.

DIAGNOSIS: Tricolporate, oblate, angulaperturate; colpi long, meridional, narrow, reaching half way or more toward polar areas; pores vestibulate, conspicuous, with atrium, equatorial; amb triangular, sides straight to convex; sexine well defined, thick, tectate, clavate or baculate, tectate or intectate.

REMARKS: Genus Senipites is easily distinguishable from the genus Symplocoipollenites Potonié 1951, in having longer colpi and mostly convex sides of the amb. Characteristically, Symplocoipollenites has colpi either restricted in vestibulate pores or barely making an exit from such pores. The same features are found in the extant representatives of the family Symplocaceae. Here, it has been felt undesirable to emend the genus Symplocoipollenites to include pollen with long colpi and rob its useful generic circumscription. Genus Senipites is proposed here for pollen having vestibulate pores and long colpi reaching at least halfway or more from the equator to the polar regions. Excepting the long colpi, other morphological features of Senipites are similar to pollen of extant genus Symplocos.

Genus Porocolpopollenites (Pflug) Thomson and Pflug, 1953, included pollen belonging to the earlier designated genera Symplocoipollenites Potonié 1951, and Symplocospollenites Potonié, Thomson and Thiergart 1950. Hence the genus Porocolpopollenites is a junior synonym. Nagy (1963) described Porocolpopollenites hidasensis as having affinity with family Symplocaceae. As described, Porocolpopollenites hidasensis Nagy, 1963, has short colpi and straight sides, hence it might be

transferred to the genus Symplocoipollenites Potonié 1951.

The form-genus Senipites is named in honor of late Dr. Jitendra Sen, an eminent palynologist and botanist from India.

Senipites drumhellerensis n. sp.

Plate XI, Figures 3-5.

DESCRIPTION: Tricolporate, oblate, angulaperturate; colpi long, narrow, meridional, reaching polar areas, pores vestibulate, with atrium, equatorial; amb triangular, sides convex; sexine about 1.6 microns thick, double layered, clavate, tectate, clavae close to each other, foot-layer thinner than baculate layer, foot-layer forms atrium on pores; ornamentation very finely reticulate, lumina about 0.5 micron, muri height about 1 micron, thickness 0.5 micron.

SIZE RANGE: Equatorial diameter 20 to 30 microns.

HOLOTYPE DIMENSION: Equatorial diameter 24.0 microns.

HOLOTYPE PREPARATION: EC 6/3 : 53.8/114.9, Pl. XI, Fig. 3.

ILLUSTRATED SPECIMENS: DH 14/1 : 65.3/124.1, Pl. XI, Fig. 4; DH 35/1 : 23.6/117.0, Pl. XI, Fig. 5.

LOCALITY: East Coulee Locality, Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Long meridional colpi crossing vestibulate, equatorial pores and reaching polar regions distinguish Senipites drumhellerensis from other similar species.

NAME DERIVATION: The specific epithet is after Drumheller, a town in souther Alberta, near sample collection site.

Genus Wilsonipites n. gen.

TYPE SPECIES: Wilsonipites nevisensis n. sp.

DIAGNOSIS: Tricolporate, oblate to spherical, angulaperturate; colpi long reaching poles, meridional, narrow; pores equatorial, small, inconspicuous; amb subtriangular to circular, sides convex; sexine very thin, scabrate, reticulations less than 1 micron.

REMARKS: Genus Wilsonipites is hereby proposed to include tricolporate pollen with long meridional colpi reaching polar areas, thin scabrate sexine, and uniformly distributed reticulate ornamentation with lumina less than one micron size.

Genus Retitricolporites van der Hammen ex van der Hammen and Wymstra, 1964, overlaps the characters of many tricolporate genera proposed earlier. For meaningful application, the genus Retitricolporites should be restricted.

The name of the genus is given in honor of Professor L. R. Wilson, Department of Geology and Geophysics, University of Oklahoma, Norman, U.S.A.

Wilsonipites nevisensis n. sp.

Plate XI, Figures 6-8.

DESCRIPTION: Tricolporate, oblately spheroidal, angulaperturate; colpi long, narrow, meridional, reaching polar areas; pores small, inconspicuous, equatorial; amb almost circular, sides convex; sexine about 0.8 to 1 micron thick, two layered, foot-layer continues around pores, outer layer scabrate; ornamentation finely reticulate, lumina size less than 1 micron.

SIZE RANGE: Polar axis 22 microns; equatorial axis 21 microns; equatorial diameter 20 to 24 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 20.8 microns.

HOLOTYPE PREPARATION: BT 22/1 : 67.2/119.0, Pl. XI, Fig. 6.

ILLUSTRATED SPECIMENS: BT 26/1 : 33.7/124.1, Pl. XI, Fig. 7; DH 36/2 : 27.6/120.9, Pl. XI, Fig. 8.

LOCALITY: Betty Tolman Locality, Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Wilsonipites nevisensis can be distinguished by long colpi, scabrate thin sexine and inconspicuous pores.

NAME DERIVATION: The specific epithet is derived from Nevis, a hamlet near the sample collection site in southern Alberta.

Genus Callistopollenites n. gen.

1961 Tricolporites radiatostriatus Mtchedlishvili in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 249, pl. 81, figs. 1a-g, 2a, b.

1965 Tricolporopollenites radiatostriatus (Mtchedlishvili in Samoilovitch and Mtchedlishvili) Bratzeva (pars); Trans. Acad. Sci. U.S.S.R., Geol. Inst., vol. 129, p. 26, pl. 10, figs. 4-8, (non pl. 13, figs. 1-3).

TYPE SPECIES: Callistopollenites radiatostriatus (Mtchedlishvili in Samoilovitch and Mtchedlishvili) n. comb.

DIAGNOSIS: Tricolporate; colpi meridional, long or short; pores large, equatorial, aspidate, oncuate; amb almost circular; sexine thick, clavate, ornamentation striate, striae disperse radially from a few centers.

REMARKS: Genus Callistopollenites is proposed here to receive tricolporate fossil pollen which have aspidate and oncuate apertures and radially dispersed striate ornamentation on clavate sexine. The form-genus Callistopollenites can be distinguished by its aspidate and oncuate apertures, and clavate sexine with radially dispersed striate ornamentation. The affinity of the genus with the modern flora is uncertain.

Callistopollenites radiatostriatus (Mtchedlishvili in Samoilovitch and Mtchedlishvili) n. comb.

Plate XI, Figures 9-11.

Synonymy as per genus.

DESCRIPTION: Tricolporate, spheroidal; colpi long, meridional, narrow, reaching poles; pores large, equatorial, aspidate, oncuate?; amb circular; sexine thick, clavate; ornamentation striate; striae radially dispersed from a few centers.

SIZE RANGE: Polar axis 30.4 to 36.0 microns; equatorial axis 28.8 to 36.8 microns. Size range of the diameter given by Samoilovitch and Mtchedlishvili (1961) 23.8 to 35.4 microns.

ILLUSTRATED SPECIMENS: DH 20/1 : 37.8/123.4, Pl. XI, Fig. 9; DH 13/1 : 65.4/122.2, Pl. XI, Fig. 10; DH 24/1 : 50/122.0, Pl. XI, Fig. 11.

LOCALITY: Drumheller Locality, lower member, Edmonton Formation; Maestrichtian.

REMARKS: Long colpi and smaller pores with lesser thickenings distinguish C. radiatostriatus from C. tumidoporus.

Mtchedlishvili (in Samoilovitch and Mtchedlishvili 1961)

described such tricolporate pollen under the form group Tricolporites which cannot be treated as a valid genus (Potonié 1960). Bratzeva (1965) transferred them under Tricolporopollenites (Pflug) Thomson and Pflug, 1953. The type-species of the genus Tricolporopollenites has been transferred by its author under the form-genus Rhoipites Wodehouse, 1933 (Potonié 1960). Therefore the genus Tricolporopollenites (Pflug) Thomson and Pflug, 1953, is invalid under Article 34(1) of the International Code of Botanical Nomenclature (Lanjouw et al. 1961). These pollen are transferred under the genus Callistopollenites.

Callistopollenites comis n. sp.

Plate XI, Figure 12.

DESCRIPTION: Tricolporate, angulaperturate, spheroidal; colpi long, narrow, meridional; pores oncuate, large equatorial; amb almost circular, slightly angular at apertures, sides convex; sexine about 1 micron thick, pilate, pila close to each other, striate, striae radially dispersed from a few centers.

SIZE RANGE: Equatorial diameter 20 to 26 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 24.0 microns.

HOLOTYPE PREPARATION: DH 6/1 : 45.2/123.1, Pl. XI, Fig. 12.

LOCALITY: Drumheller Locality, lower member, Edmonton Formation; Maestrichtian.

REMARKS: Sexine of C. comis is distinctly pilate and intectate. C. comis is smaller in size than C. tumidoporus.

NAME DERIVATION: Latin comis = amiable.

Callistopollenites tumidoporus n. sp.

Plate XII, Figures 1-3.

1965 Tricolporopollenites radiatostriatus (Mtchedlishvili in Mtchedlishvili and Samoilovitch) Bratzeva (pars); Trans. Acad. Sci. U.S.S.R., Geol. Inst., vol. 129, p. 27, pl. 13, figs. 1-3.

DESCRIPTION: Tricolporate, angulaperturate, spheroidal; colpi short, meridional, extending beyond pore areas; pores oncuate, equatorial; amb almost circular, slightly angular at apertures, sides convex; sexine thin, two layered, pilate, pila loosely tectate, striate, striae radially dispersed from a few centers, capita distinctly visible on striations giving a beady appearance to striations.

SIZE RANGE: Equatorial diameter 40 to 44 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 44 microns.

HOLOTYPE PREPARATION: BT 30/1 : 28.0/120.0, Pl. XII, Figs. 1, 2.

ILLUSTRATED SPECIMENS: BT 30/2 : 50.0/122.8, Pl. XII, Fig. 3.

LOCALITY: Betty Tolman Locality, lower member, Edmonton Formation; Maestrichtian.

REMARKS: Apertures of Callistopollenites tumidoporus are oncuate rather than vestibulate apertures of the genus Beaupreaidites. Swollen protruding, crescentic pores are characteristic in distinguishing C. tumidoporus.

Bratzeva (1965) described a few forms as Tricolporopollenites radiatostriatus which are identical to Callistopollenites tumidoporus.

NAME DERIVATION: Latin tumidus = swollen.

Genus Tetracolpites Vimal ex Srivastava 1966

TYPE SPECIES: Tetracolpites reticulatus Srivastava 1966.

REMARKS: The genus Tetracolpites embraces those pollen which have long wedge-shaped colpi and reticulate ornamentation (retipilate included). Stephanocolpites van der Hammen emend. Potonié, 1960, includes brevicolpate forms with reticulate or foveolate sexine. Tetracolpate pollen having long or short colpi and scabrate sexine are classified under the genus Scabrastephanocolpites van der Hammen and de Mutis, 1966.

Tetracolpites pulcher n. sp.

Plate XII, Figure 4.

DESCRIPTION: Isopolar; tetracolpate, colpi long, meridional, reaching the polar region, wedge shaped; amb four cornered, corners rounded, sides straight to slightly convex; sexine about one micron thick, tectate, retipilate; reticulations large, about 1 to 1.5 microns in size; lumina bound by 5 to 6 capita, lumina polygonal.

HOLOTYPE DIMENSIONS: Equatorial dimensions 40 x 52 microns.

HOLOTYPE PREPARATION: DH 16/1 : 47.7/120.1, Pl. XII, Fig. 4.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Retipilate ornamentation distinguishes T. pulcher from T. reticulatus which has fine reticulate sexine.

NAME DERIVATION: Latin pulcher = handsome, pretty.

Genus Erdtmania n. gen.

TYPE SPECIES: Erdtmania superba n. sp.

DIAGNOSIS: Isopolar; 6-colpate, meridional, 3 alternate colpi long, reaching poles, other 3 alternate colpi short; polar axis shorter than equatorial axis; sexine thick, tectate; ornamentation reticulate, retipilate etc.

REMARKS: The genus Erdtmania is distinguished by the hexacolpate condition of pollen where alternately one colpi is long and one short. Longer colpi almost reach poles. The polar axis is shorter than equatorial axis.

The generic name is given in honor of Professor G. Erdtman, Palynology Laboratory, Stockholm, Sweden.

Erdtmania superba n. sp.

Plate XII, Figure 5.

DESCRIPTION: Isopolar; 6-colpate, colpi meridional, alternately one colpi long reaching poles and the other short, thus three colpi long and three are short; amb ellipsoidal, polar axis shorter than equatorial axis; sexine distinctly three layered; foot-layer smooth, thin; middle layer baculate, baculae sparsely situated - about 1.3 microns apart; outermost layer capitate, capita at greater distances, joined by a tectate smooth layer; ornamentation reticulate; capita seen at the corners of reticulum joined by tectate layer; reticulum large, lumina size about 2.5 to 3.5 microns; muri thickness about 0.8 micron.

HOLOTYPE DIMENSIONS: Equatorial dimensions 37.6 x 28.8 microns.

HOLOTYPE PREPARATION: DH 33/1 : 35.3/121.9, Pl. XII, Fig. 5.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Erdtmania superba has rare occurrence in the Edmonton Formation. Its taxonomic affinity with any extant taxon is not certain.

NAME DERIVATION: Latin superba = excellent, superb.

Genus Scabrastephanocolpites van der Hammen and de Mutis 1966

TYPE SPECIES: Scabrastephanocolpites scabratus van der Hammen and de Mutis 1966.

REMARKS: Scabrastephanocolpites accommodates pollen with more than three colpi and scabrate sexine. Colpi may be long or short. Polycolpites Couper emended Srivastava 1966, has more than four long colpi reaching polar areas with psilate, clavate or baculate sexine. Genus Tetracolpites Vimal ex Srivastava 1966, embraces pollen with four long colpi reaching polar areas and having reticulate ornamentation. Genus Stephanocolpites van der Hammen emended Potonié, 1960, is restricted for pollen with more than three short, meridional colpi, and having reticulate to foveolate sexine. Genus Nothofagidites (Erdtman) Potonié 1960, has 4-9 short colpi with annulus around them. Nothofagidites has granulate to papillate sexine. Species having more than three colpi in the Genus Cranwellia Srivastava emend. can be distinguished by the striate pattern of granules on the sexine.

Scabrastephanocolpites albertensis n. sp.

Plate XII, Figure 6.

DESCRIPTION: Isopolar, 6-colpate, colpi short, meridional, wedge-shaped; amb circular, poles flattened, polar axis compressed; apocolpia large, mesocolpia narrow, sides slightly convex; sexine thickness about 1 micron, tectate, slightly scabrate, infrareticulate.

SIZE RANGE: Equatorial diameter 25 to 30 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 26.4 microns.

HOLOTYPE PREPARATION: EC 5/1 : 45.9/111.8, Pl. XII, Fig. 6.

LOCALITY: East Coulee Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Scabrastephanocolpites albertensis can be distinguished by six short colpi and slightly scabrate sexine. S. lisamae van der Hammen and de Mutis, 1966, from the Paleocene of Columbia, seems to have longer colpi and the number of colpi is not certain (?6). S. albertensis has a shorter polar axis than S. lisamae.

Scabrastephanocolpites lepidus n. sp.

Plate XII, Figure 7.

DESCRIPTION: Isopolar, tetracolpate, colpi short, meridional, wedge-shaped; amb circular, poles flattened, apocolpia large, sides convex; sexine thin, tectate, scabrate.

SIZE RANGE: Equatorial diameter 24 to 28 microns.

HOLOTYPE DIMENSION: Equatorial diameter 25.6 microns.

HOLOTYPE PREPARATION: BT 23/1 : 26.7/114.3, Pl. XII, Fig. 7.

LOCALITY: Betty Tolman Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: S. lepidus has smaller size, shorter colpi and larger apocolpia than S. vanegensis van der Hammen and de Mutis 1966, described from the Paleocene of Columbia.

NAME DERIVATION: Latin lepidus = pleasant, charming.

Genus Marcellopites n. gen.

TYPE SPECIES: Marcellopites tolmanensis n. sp.

DIAGNOSIS: Triorate, oblate, angulaperturate; ora meridional or equatorial; amb triangular to circular, sides slightly concave to convex; sexine thick; infratextured to finely scabrate.

REMARKS: Couper (1953) diagnosed the genus Triorites Cookson ex Couper, 1953, to include triorate pollen of variable sizes, and having psilate to sculptured sexine. He designated the heavily ornamented Triorites magnificus Cookson, 1950, as its type species. Potonié (1960) restricted Triorites Cookson ex Couper to clavate triorate forms only.

The form-genus Marcellopites is proposed here to include triorate, psilate to finely scabrate pollen. The genus is named after Marcello Malpighi (1628-1694), pioneer in the galaxy of pollen workers.

Marcellopites tolmanensis n. sp.

Plate XII, Figure 8.

DESCRIPTION: Triorate, oblate, angulaperturate; ora large, about 9.6 x 9.6 microns size, meridional; amb triangular with rounded

angles, sides straight to slightly convex; sexine about 3.2 microns thick, two layered, tectate, foot-layer about 2.4 microns thick, smooth; foot-layer does not extend on the rims of ora; tectate-layer about 0.8 micron thick, infragranulate; tectate-layer forms rims of ora; ornamentation faintly irregular infrareticulate, surface smooth.

SIZE RANGE: Equatorial diameter 33 to 40 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 36.0 microns.

HOLOTYPE PREPARATION: BT 19/1 : 27.1/113.0, Pl. XII, Fig. 8.

LOCALITY: Betty Tolman Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Marcellopites tolmanensis can be distinguished by its large ora, thick foot-layer of sexine, and smooth surface. Its botanical affinities are not certain. Morphological features of M. tolmanensis suggest their being entomophilous pollen and so incapable of long distance wind transportation.

NAME DERIVATION: The specific epithet is derived from the Tolman Ferry site near Trochu in southern Alberta.

Marcellopites basilicus n. sp.

Plate XII, Figure 9.

DESCRIPTION: Triorate, oblately spheroidal, angulaperturate; ora large, size 7 x 3.2 microns, equatorial, with annulus; amb subtriangular, sides straight to convex; sexine about 1.6 microns thick, two layered, foot-layer thickness about 1 micron, smooth, outer-layer thickness about 0.6 micron, tectate, baculate; ornamentation infrareticulate,

lumina size less than 1 micron, annulus is formed by both the layers of sexine.

SIZE RANGE: Equatorial diameter 30 to 35 microns.

HOLOTYPE DIMENSIONS: Equatorial diameter 34.4 microns.

HOLOTYPE PREPARATION: MB 2/2 : 40/121.4, Pl. XII, Fig. 9.

LOCALITY: Morrin Bridge Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Marcellopites basilicus is distinguishable from M. tolmanensis in having equatorial ora with annulus.

NAME DERIVATION: Latin basilicus = royal.

cf. Orbiculapollis globosus (Chlonova) Chlonova 1961

Plate XII, Figure 10.

DESCRIPTION: Triporocolpoidate, oblate, angulaperturate; colpi meridional, small, situated at distal ends of equatorial projections; pores equatorial, deep in the center of colpi, small, circular in outline; amb circular, sides convex; sexine thickness about 1 micron, sexine layers not differentiated, slightly scabrate.

SIZE RANGE: Polar axis 21.6 microns; equatorial axis 24.0 microns.

ILLUSTRATED SPECIMENS: EC 8/1 : 41/126.9, Pl. XII, Fig. 10.

LOCALITY: East Coulee Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Genus Orbiculapollis Chlonova 1961, is tricolpoid whereas the specimen described above has distinct pores in the center of colpi at the apical ends of equatorial projections.

Genus Aquilapollenites Rouse emend. Funkhouser restr.

1957 Aquilapollenites Rouse; Can. J. Botany, vol. 35, p. 370.

1961 Aquilapollenites Rouse emend. Funkhouser; Micropaleontology, vol. 7, no. 2, p. 193.

1961 Parviprojectus Mtchedlishvili in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 125.

1961 Taurocephalus Simpson; Trans. Roy. Soc. Edin., vol. 64, no. 16, p. 440.

TYPE SPECIES: Aquilapollenites quadrilobus Rouse 1957.

DIAGNOSIS: Heteropolar or isopolar pollen, one or both the poles extended forming polar projections; three equatorial projections; tricolpate or tridemicolpate on each side of equatorial projections; sometimes either in addition to or without meridional colpi, three equatorial colpi may be situated between, or on, the equatorial projections; ornamentation variable.

RESTRICTIONS: Pollen without defined polar projections and having equatorial projections may be excluded from this genus.

Pollen having one polar projection developed and the other reduced to insignificance or concavity may be transferred elsewhere. For the sake of precision, it is proposed here that pollen, where the length from the center of the equatorial axis to the tip of the reduced polar projection is half, or more than half, of the similar length of the other polar projection, be only treated in this genus (figure 8).

Porate pollen having polar or equatorial projections may not be included in Aquilapollenites.

REMARKS: Since Rouse (1957) designated the fossil pollen genus Aquilapollenites, many species have been found abundantly distributed

in the Upper Cretaceous and Paleocene beds of the circum-Pacific region and Siberia (Rouse 1957; Funkhouser 1961; Stanley 1961, 1965; Norton 1965; Srivastava 1965, 1966, 1967; Sato 1961; Takahashi 1964, 1965; Bratzeva 1965; Chlonova 1961, 1962; Samoilovitch and Mtchedlishvili 1961; Samoilovitch 1965). A few species have been reported from Africa also (Jardine and Magloire 1965; Belsky, Boltenhagen, and Potonié 1965). Although Periporopollenites pentagulus described by Thompson and Pflug (1953) from Germany (Paleocene to the Oligocene beds) and Pentapollenites pentagulus (Pflug) Krutzsch 1957, do not conclusively conform with the generic circumscription of Aquilapollenites, the illustrated specimens with reference to the generic diagnosis of Taurocephalus Simpson 1961, are morphologically comparable to the genus Aquilapollenites. This indicates that the sediments in Europe also contain pollen referable to Aquilapollenites, contrary to the expressed views that these are restricted to the circum-Pacific region and Siberia. Proteacidites pachypolus from the early Tertiary of Australia (Cookson and Pike 1954) has only apparent similar morphology.

Funkhouser (1961) emended the generic diagnosis of Aquilapollenites Rouse 1957, which in its circumscription embraces many pollen with diverse morphology. Thus Aquilapollenites has become a eurypalynous genus and might lose its meaningful application in stratigraphy and taxonomy.

Funkhouser (1961), in the generic diagnosis of Aquilapollenites, did not mention the complete loss of one polar projection or developing concavity at one of the poles. However, he mentioned such a possibility in one of the preceeding paragraphs.

The genus Aquilapollenites is restricted here to only isopolar and heteropolar pollen which have three or more equatorial projections and

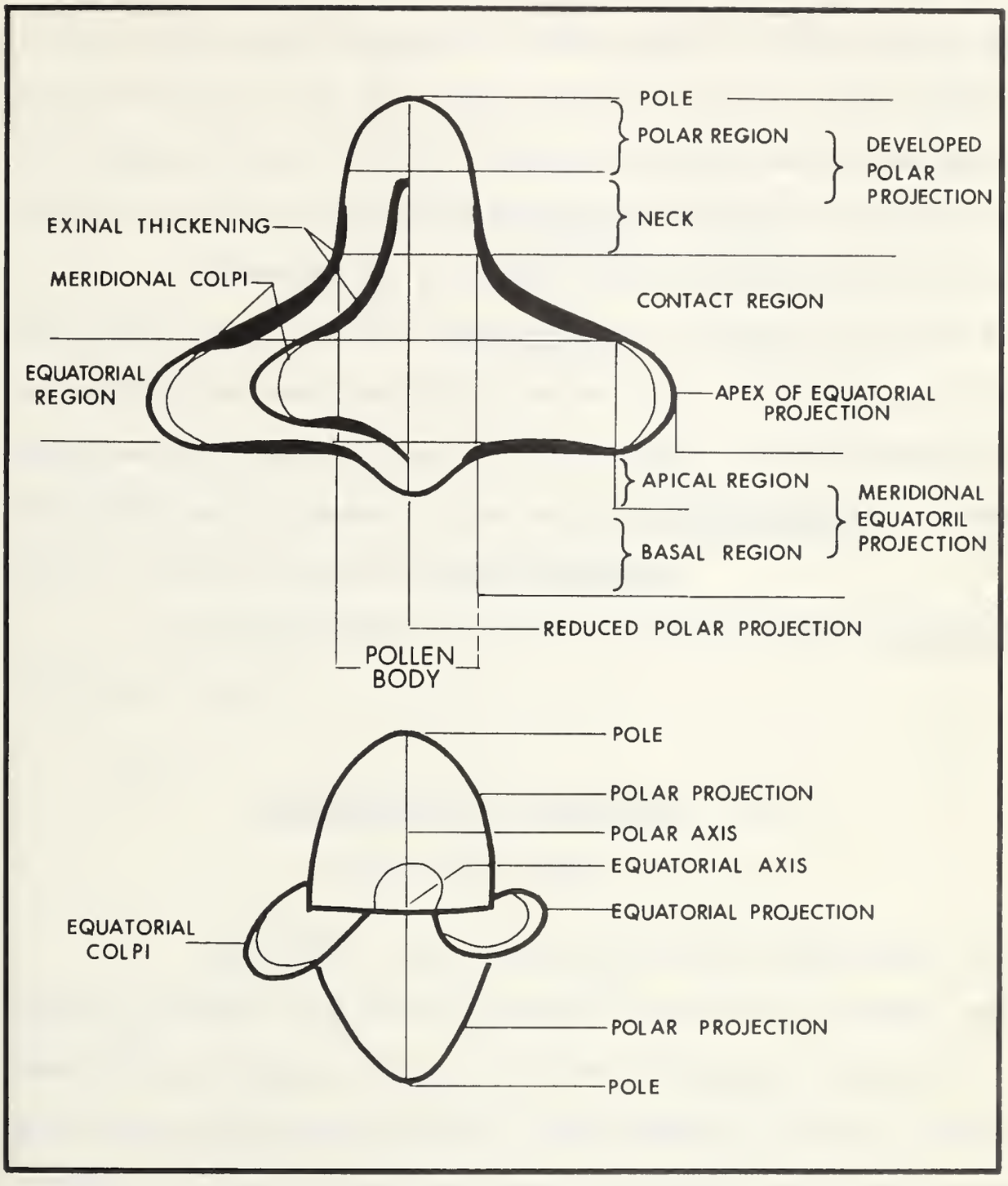

Fig. 7. Diagrammatic sketches showing parts of heteropolar and subisopolar Aquilapollenites and terminology used.

one polar projection at each pole. Pollen are either tricolpate or tridemicolpate; sometimes the colpi run equatorially also. Among the heteropolar pollen only those pollen are included which have the length of the reduced polar projection at least half the length of the other polar projection (fig. 8). Pollen having the length of the reduced polar projection less than half the length of the other polar projection are to be included in the genus Mancicorpus Mtchedlishvili 1961, emend.

Mtchedlishvili (in Samoilovitch and Mtchedlishvili 1961) designated the pollen-genus Parviprojectus to include all pollen with a large body and small equatorial projections. The definition of this genus has been arbitrarily put and thus cannot be used meaningfully for separating the two genera. Hence the genus Parviprojectus is treated here as a junior synonym of Aquilapollenites.

The terminology used here for various parts of Aquilapollenites is shown in fig. 7.

Aquilapollenites accipiteris n. sp.

Plate XIII, Figures 1-6.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; isopolar, polar projections flattened, round, short; equatorial projections meridional, long, broader at the base, constricted in middle, apices flattened and round; tricolpate, colpi long, meridional across equatorial projections on both sides, reaching the base of equatorial projections but not extending on polar projections; sexine tectate, baculate, 1 micron thick, slightly thickens meridionally on equatorial

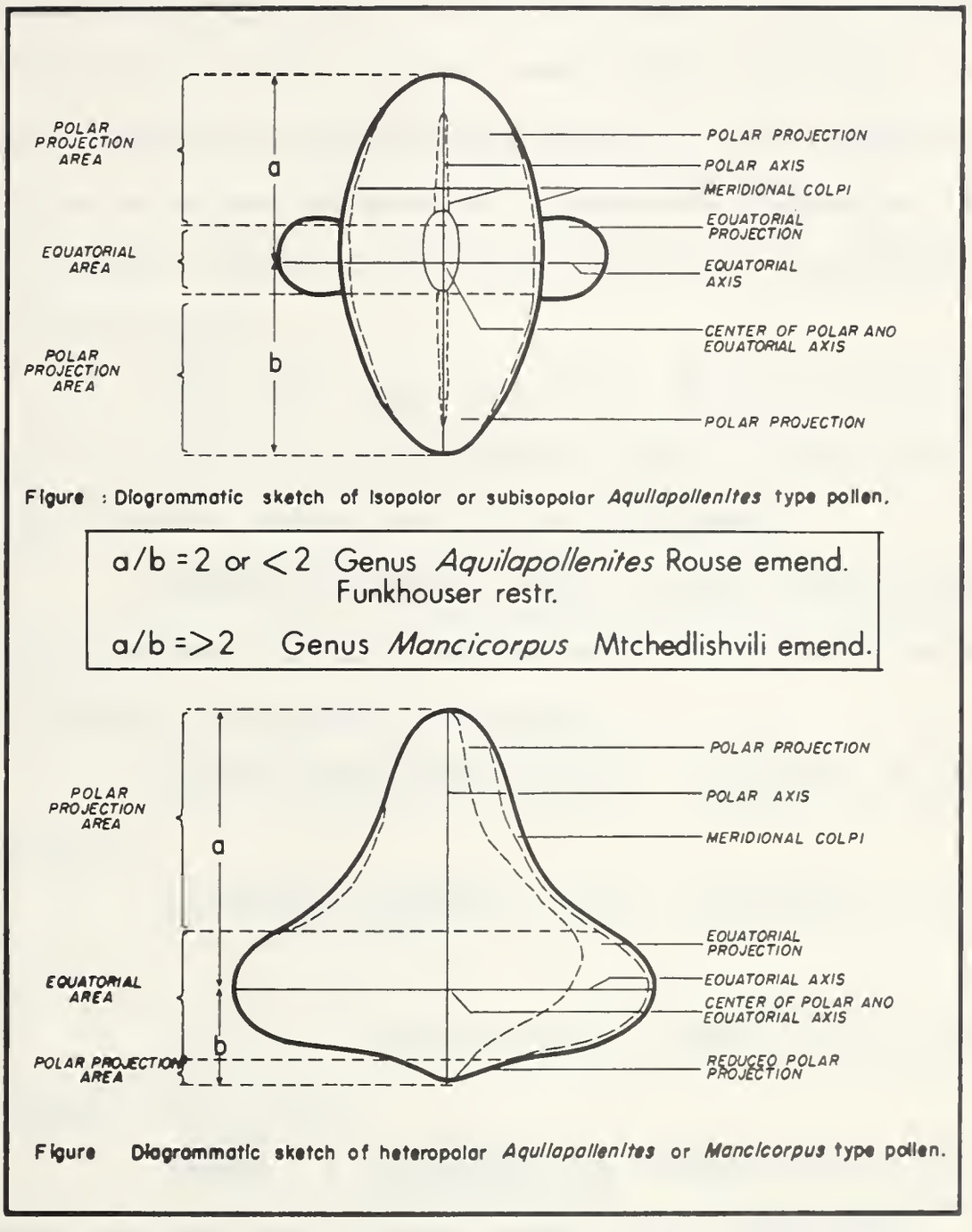

Fig. 8. Diagrammatic sketches of pollen showing characteristics distinguishing Aquilapollenites and Mancicorpus.

projections, thin on the apices of equatorial projections only, ornamentation infrareticulate with scattered spinules, sexine thickness at polar projections 1 micron, 1.5 to 2.0 microns thick on meridional areas of equatorial projections, reticula size about 1 micron, breadth of spinules at base about 2 microns, length about 2.5 microns, acuminate, spinules sparsely but uniformly distributed on polar projections, their distribution extends meridionally on equatorial projections, bordering colpi margins, equatorial area except the apices of equatorial projections free from spinules.

SIZE RANGE: Polar axis 34.0 to 38 microns; equatorial axis 20.0 to 25.0 microns; distance from the center of polar axis to the tip of the equatorial projections 32.0 to 40.0 microns.

HOLOTYPE DIMENSIONS: Polar axis 36.0 microns; equatorial axis 20.0 microns; distance from the center of polar axis to the tip of the equatorial projections 35.2 microns.

HOLOTYPE PREPARATION: DH 26/1 : 31.4/125.2, Pl. XIII, Figs. 1-3.

ILLUSTRATED SPECIMENS: DH 4/2 : 58.3/119.1, Pl. XIII, Figs. 4-6.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: A. accipiteris has smaller polar projections, larger colpi and fewer spinules compared to A. ascriptivus.

NAME DERIVATION: Latin accipiter = a hawk.

Aquilapollenites aptus n. sp.

Plate XIV, Figures 1, 2.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; subisopolar, polar projections reduced, one polar projection broader and round, other polar projection bluntly conical; equatorial projections well developed, meridional, arising from polar areas; gently grading out, apices round; tricolpate, colpi short, meridional across the apices of equatorial projections, restricted within apical regions; sexine echinate, thickens meridionally extending up to the apical regions of equatorial projections, spinules more densely distributed on polar projections than rest of pollen-body, base of spinules wide, acuminate.

SIZE RANGE: Polar axis 25.0 to 30.0 microns; equatorial axis 12.0 to 17.0 microns; distance from the center of polar axis to the tips of equatorial projections 9.0 to 12.0 microns.

HOLOTYPE DIMENSIONS: Polar axis 27.2 microns; equatorial axis 12.8 microns; distance from the center of polar axis to the tips of equatorial projections 15.2 microns; breadth of apical regions of equatorial projection 9.6 microns.

HOLOTYPE PREPARATION: DH 35/1 : 55.4/122.8, Pl. XIV, Figs. 1, 2.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: A. aptus is smaller in size than A. firmus.

Equatorial projections of A. aptus arise from extreme ends of polar projections while in A. firmus and A. comosus, equatorial projections arise from about mid point of polar projections.

NAME DERIVATION: Latin aptus = suitable, fit, appropriate.

Aquilapollenites argutus n. sp.

Plate XIV, Figure 3.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; subisopolar, polar projections not well developed, one polar projection bluntly conical and larger, the other polar projection broad and rounded; equatorial projections well developed, meridional, arising from almost polar areas and gently grading into rounded apices; tricolpate, colpi short, meridional across the apices of equatorial projections, restricted within apical regions; sexine echinate, thickens meridionally extending up to the apical regions of equatorial projections, spinules more densely distributed on polar projections than rest of pollen-body, base of spinules broad, acuminate.

HOLOTYPE DIMENSIONS: Polar axis 25.6 microns; equatorial axis 15.2 microns; distance from the center of the polar axis to the tips of equatorial projections 16.8 microns; breadth of apical regions of equatorial projections 12.8 microns.

HOLOTYPE PREPARATION: DH 35/1 : 43.5/126.3, Pl. XIV, Fig. 3.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: A. argutus has shorter polar axis, larger equatorial axis and broader apical regions of equatorial projections as compared to those of A. aptus. In A. argutus equatorial projections arise slightly below the extreme end of polar axis at one polar projection. In A. aptus equatorial projections arise from the extreme ends of polar axis on both polar projections.

NAME DERIVATION: Latin argutus = sharply defined, distinct.

Aquilapollenites ascriptivus n. sp.

Plate XIV, Figures 4-7.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; isopolar to subisopolar, polar projections flattened to rounded, well developed; equatorial projections meridional, long, broad at the base, narrower at the apices; tricolpate, colpi meridional across the apices of equatorial projections, extending almost half the length of equatorial projections on both sides; sexine tectate, baculate, meridionally thicker at the contact of equatorial and polar projections, maximum thickness about 4.5 microns, thickened areas smooth, ornamentation infrareticulate and with scattered spinules, reticulations of uniform size, about 1 micron large, breadth of spinules at base about 1.5 to 2 microns, length about 2.5 microns, acuminate, equatorial region free from spinules except at the apices of equatorial projections, mostly spinules are at polar projections and extend in their distribution meridionally on equatorial projections across the apices bordering the margins of colpi.

HOLOTYPE DIMENSIONS: Polar axis 42.4 microns; equatorial axis 20.0 microns; distance from the center of the polar axis to the tips of equatorial projections 35.2 microns.

HOLOTYPE PREPARATION: DH 22/1 : 60.3/116.2, Pl. XIV, Figs. 4-7.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Aquilapollenites ascriptivus has a longer body and narrower apices of equatorial projections than A. accipiteris.

NAME DERIVATION: Latin ascriptivus = enrolled as a supernumerary.

Aquilapollenites aucellatus n. sp.

Plate XV, Figures 1, 2.

1961 Aquilapollenites unicus (Chlonova) Chlonova; Trudy Inst. Geol. Geophys. SOAN SSSR, Novosibirisk, vol. 7, p. 83, pl. 14, figs. 106, 106a.

non 1957 Triporina unica Chlonova; Izv. Novtchnykh filialov AN SSSR, no. 2, p. 44, pl. 1, figs. 1-3.

non 1960 Triporina unica Chlonova; Trudy Inst. Geol. Geophys. SOAN SSSR, Novosibirisk, vol. 3, p. 75, pl. 10, fig. 42.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; isopolar to subisopolar, polar projections rounded; equatorial projections well developed, shape almost similar to polar projections, size slightly larger than polar projections, broader at the base than apex; tricolpate, colpi short, meridional across the apices of equatorial projections; sexine tectate, baculate, about 1

micron thick at polar projections, thick meridionally at the contacts of equatorial projections and polar projections, sexinal thickenings smooth, maximum thickness 2.5 microns, spinules scattered all over the surface, thickened areas of sexine free from spines, breadth of spinules at base less than 1 micron, length about 1.5 microns; ornamentation infrareticulate, reticula size less than 1 micron.

HOLOTYPE DIMENSIONS: Polar axis 40.8 microns; equatorial axis 17.6 microns; distance from the center of the polar axis to the tips of equatorial projections 23.2 microns.

HOLOTYPE PREPARATION: DH 4/1 : 53.6/124.0, Pl. XV, Figs. 1, 2.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Chlonova (1957) described three specimens as Triporina unica without designating a holotype. Chlonova (1961) transferred Triporina unica under the genus Aquilapollenites and formed a new combination Aquilapollenites unicus. The specimen illustrated by Chlonova (1961) does not compare with the original ones. However Samoilovitch and Mtchedlishvili (1961) transferred all the three original specimens described by Chlonova (1957) as Triporina unica to Triprojectus dispositus Mtchedlishvili, T. unicus (Chlonova) Mtchedlishvili and Aquilapollenites quadrilobus Rouse. The polar projections in Aquilapollenites quadrilobus are longer and narrower than the equatorial projections. In Aquilapollenites aucellatus, the polar projections are shorter than the equatorial projections.

NAME DERIVATION: Latin aucella = small bird.

Aquilapollenites augustus n. sp.

Plate XV, Figures 3-6; Plate XVI, Figures 1-4.

1966 Aquilapollenites amplus Stanley, in Srivastava; Pollen et Spores, vol. 8, no. 3, p. 540, pl. 8, figs. 10-12.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; isopolar to slightly subisopolar, polar projections well developed, rounded; equatorial projections meridional, long, equal width throughout the length except slightly broader at the base and rounded at apices; tricolpate, colpi, short, meridional across the apices of equatorial projections, restricted within thinner apical region; sexine tectate, baculate with spinules, 1 to 1.5 microns thick at polar regions, thickens meridionally at the contact of polar and equatorial projections up to 3 to 5 microns, sexine thin at the apices of equatorial projections; ornamentation infrareticulate, reticulations about 1 micron large, spinules present all over pollen body except central equatorial regions of equatorial projections, spinules mostly concentrated at polar projections and apical regions of equatorial projections, breadth of spinules at base about 1.5 microns, length 1.5 microns, acuminate.

SIZE RANGE: Polar axis 52.0 to 63.0 microns; equatorial axis 28.0 to 33.0 microns; distance from the center of the polar axis to the tip of the equatorial projections 32.0 to 44.0 microns; width of equatorial projections 16 to 24 microns.

HOLOTYPE DIMENSIONS: Polar axis 57.6 microns; equatorial axis 28.8 microns; distance from the center of the polar axis to the tip of the equatorial projections 37.6 microns; width of equatorial

projections 18 microns.

HOLOTYPE PREPARATION: DH 33/2 : 51.7/126.2, Pl. XV, Figs. 3-5.

ILLUSTRATED SPECIMENS: Sc 2-6/1 : 48.6/111.0, Pl. XV, Fig. 6; DH 20/1 : 31.7/114.1, Pl. XVI, Fig. 1; DH 33/2 : 46.3/114.4, Pl. XVI, Fig. 2; DH 28/1 : 39.5/126.2, Pl. XVI, Fig. 3; BT 4/1 : 56.2/115.2, Pl. XVI, Fig. 4.

LOCALITY: Drumheller Locality, Betty Tolman Locality, Scollard Locality 2, Edmonton Formation; Maestrichtian.

REMARKS: Projectoporites Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961, has three equatorial projections containing pores. Aquilapollenites augustus is tricolpate. The breadth of equatorial projections of A. augustus is almost double that of Projectoporites.

NAME DERIVATION: Latin augustus = majestic, dignified.

Aquilapollenites barbatus n. sp.

Plate XVI, Figure 5.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; subisopolar, both polar projections considerably reduced but one is smaller than the other, larger polar projection rounded, smaller bluntly conical; equatorial projections long, meridional, broader at base only, uniform width throughout the length, apices round; tricolpate, colpi small, meridional across the apices of equatorial projections, restricted on apical region with thin sexine; sexine

tectate, baculate with spinules, 1.5 microns thick at polar areas, thickens meridionally extending up to the apical region, maximum width of thickened area 5 microns; ornamentation infrareticulate, reticula size about 1 micron or less, larger reticula restricted to polar regions and apical regions of equatorial projections, breadth of spinules at base about 2.5 microns, length 2.5 to 3.5 microns, acuminate, densely distributed on polar projections and apical regions of equatorial projections, sparsely on equatorial region of pollen-body, a row of spines extend meridionally on equatorial projections from pole to pole; equatorial region and thickened areas of equatorial projections free from spines and spinules.

HOLOTYPE DIMENSIONS: Polar axis 35.2 microns; equatorial axis 14.4 microns; distance from the center of polar axis to the tip of equatorial projections 31.2 microns; average width of equatorial projections 14.4 microns.

HOLOTYPE PREPARATION: Sc 2-B/4 : 55.5/125.4, Pl. XVI, Fig. 5.

LOCALITY: Scollard Locality 2, upper division, Edmonton Formation; Maestrichtian.

REMARKS: Long equatorial projections, acutely reduced polar projections and large spines (length more than 3 microns) distinguish A. barbatus from other similar species.

NAME DERIVATION: Latin barbatus = bearded.

Aquilapollenites comosus n. sp.

Plate XVI, Figure 6.

DESCRIPTION: Pollen grains with three equatorially situated

apical projections and with one projection each on the proximal and distal polar region; subisopolar, polar projections small, one polar projection smaller and more conical than the other; equatorial projections well developed, broad, short, meridional, arising almost from the polar areas, extending into well rounded apices; tricolpate, colpi medium sized, meridional across the apical region of equatorial projections, extending up to half the length of equatorial projections on both sides of apical region; sexine tectate, baculate, echinate, thickens meridionally at the contacts of equatorial and polar projections; spinules acuminate with broad base, distributed densely on polar projections compared to equatorial region; ornamentation infrareticulate.

HOLOTYPE DIMENSIONS: Polar axis 36.8 microns; equatorial axis 15.2 microns; distance from the center of polar axis to the tips of equatorial projections 18.4 microns; average apical breadth of equatorial projections 17.6 microns.

HOLOTYPE PREPARATION: DH 39/1 : 49.6/120.8, Pl. XVI, Fig. 6.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: A. comosus has larger spinules, broader equatorial projections, thinner sexine and more reduced polar projections than A. pumilis.

NAME DERIVATION: Latin comosus = hairy.

Aquilapollenites drumhellerensis n. sp.

Plate XVI, Figure 7.

DESCRIPTION: Pollen grains with three equatorially situated

apical projections and with one projection each on the proximal and distal polar region; heteropolar, polar projections well developed, larger polar projection rounded, smaller one bluntly conical; equatorial projections meridional, larger than polar projections, broader at base, rounded apices; tricolpate, colpi short, meridional across the apices of equatorial projections, confined within apical region with thinner sexine; sexine tectate, baculate, echinate, about 1 micron thick at polar regions, thickens meridionally up to the apical regions of equatorial projections, thickened areas smooth except a meridional row of spinules on equatorial projections, ornamentation infrareticulate and spinulose, reticula less than 1 micron, spinules scattered all over pollen-body, dense on polar projections, breadth of spinules at base about 1 micron, length 1.6 microns, acuminate.

HOLOTYPE DIMENSIONS: Polar axis 40.0 microns; equatorial axis 13.6 microns; distance from the center of polar axis to the tips of equatorial projections 27.2 microns; average breadth of equatorial projections 12.0 microns.

HOLOTYPE PREPARATION: DH 42/1 : 63.5/117.2, Pl. XVI, Fig. 7.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: A. drumhellerensis has reduced polar projection larger than that of A. spinulosus. Developed polar projection and equatorial projections of A. drumhellerensis are narrower than those of A. spinulosus.

NAME DERIVATION: The specific epithet is given after the town Drumheller near the sample collection locality.

Aquilapollenites firmus n. sp.

Plate XVI, Figure 8.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on proximal and distal polar region; heteropolar, one polar projection well developed, large, round, other polar projection very much reduced, bluntly conical; equatorial projections well developed, meridional, base broad, apical region rounded; tricolpate, colpi short, meridional at the apices of equatorial projections; sexine tectate, baculate, echinate, thickens meridionally up to the apices of equatorial projections, spinule bases broad, acuminate, dense at polar projections compared to equatorial region of body; ornamentation infrareticulate.

HOLOTYPE DIMENSIONS: Polar axis 40.0 microns; equatorial axis 28.0 microns; distance from the center of polar axis to the tips of equatorial projections 24.0 microns; breadth of equatorial projections near apical region 16.0 microns.

HOLOTYPE PREPARATION: DH 33/1 : 69.7/113.9, Pl. XVI, Fig. 8.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Larger size of pollen with broader equatorial projections distinguish A. firmus from other similar species.

NAME DERIVATION: Latin firmus = strong, stout.

Aquilapollenites hirsutus n. sp.

Plate XVII, Figure 1.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; heteropolar, one polar projection well developed, broadly rounded like the shape of a dome, other polar projection very much reduced, conical; equatorial projections well developed, meridional, rounded apices; tricolpate, colpi short, meridional across the apices of equatorial projections, restricted within the apical regions; sexine tectate, baculate, echinate, thickens meridionally at the contact of polar and equatorial projections; ornamentation infrareticulate, spinules on the polar projections larger, acuminate, densely and uniformly distributed, spinules on equatorial region shorter, acuminate and sparsely distributed, tips of spinules directed toward polar projections.

HOLOTYPE DIMENSIONS: Polar axis 32.8 microns; equatorial axis 24.0 microns; distance from the center of polar axis to the tips of equatorial projections 21.6 microns; apical width of equatorial projections 11.2 microns.

HOLOTYPE PREPARATION: BT 2/1 : 51.6/123.0, Pl. XVII, Fig. 1.

LOCALITY: Betty Tolman Locality, middle division, Edmonton Formation; Maestrichtian.

REMARKS: A. hirsutus is very similar to A. polaris Funkhouser in general morphology. A. polaris has a band of densely distributed spinules at the base of polar projections which is absent in A. hirsutus. There is no constriction of the larger polar projection

at its contact with equatorial projection which is characteristic of A. polaris. Spinules of A. hirsutus at polar projections are larger than those of A. polaris.

NAME DERIVATION: Latin hirsutus = hairy.

Aquilapollenites hispidus n. sp.

Plate XVII, Figures 2, 3.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; subisopolar, polar projections rounded, well developed; equatorial projections meridional, long, broader base at the contact with polar projections, apices round; tricolpate, colpi medium, meridional across the apices of equatorial projections, extend only half the length of equatorial projections on either side; sexine tectate, baculate, echinate, thickness at poles about 1 micron, thickens meridionally at the contacts with equatorial projections and again becomes thin at their apices; ornamentation infrareticulate, reticula size about 1 micron, spinules closely distributed at polar projections, extend their distribution meridionally on equatorial projections, concentrate again at apices of equatorial projections, sparsely distributed on equatorial regions of pollen-body, absent from small areas in equatorial regions of equatorial projections which has thinner sexine, breadth of spinules at base 1.6 microns, length 1.5 to 2 microns, acuminate.

HOLOTYPE DIMENSIONS: Polar axis 68.0 microns; equatorial axis 28.0 microns; distance from the center of the polar axis to the tips of equatorial projections 40.0 microns; average breadth of equatorial

projections 16.0 microns.

HOLOTYPE PREPARATION: Sc 1-23/1 : 68.7/110.1, Pl. XVII, Figs. 2, 3.

LOCALITY: Scollard Locality 1, middle division, Edmonton Formation; Maestrichtian.

REMARKS: Large size, rounded polar projections, densely spinulose polar and equatorial projections and presence of spinules in equatorial regions of body distinguishes A. hispidus from other similar species.

NAME DERIVATION: Latin hispidus = rough, hairy, bristly.

Aquilapollenites paplionis n. sp.

Plate XVII, Figures 4-7.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; heteropolar, one polar projection large, well developed, round, other polar projection like a short protuberance, conical; equatorial projections long, meridional, well developed, apices round, almost of equal width throughout the length of equatorial projections; tricolpate, colpi meridional across the apices of equatorial projections, extending up to 1/3rd length of the equatorial projection on either side; sexine tectate, baculate, echinate; sexine bastionate, forming large reticulations, tectate, baculate at polar region; sexine reticulate at reduced polar projection, reticulations become smaller toward body and equatorial projections; sexine thickens meridionally up to 2.5 microns on equatorial projections, becomes thin again in the

apical region, infrareticulate at equatorial region of body and equatorial projections, spinules densely distributed at polar and apical regions of equatorial projections, spinule distribution extends meridionally forming almost a linear row on sexinal thickenings of equatorial projections, become dense in apical regions bordering colpi margins, two rows of spinules on equatorial region also, spinules absent in the area between equatorial and meridional rows of spinules in the equatorial region of pollen-body, breadth of spinules at base about 1 micron, length 1.2 microns, acuminate.

SIZE RANGE: Polar axis 35.0 to 38.0 microns; equatorial axis 16.0 to 20 microns; distance from the center of polar axis to the tips of equatorial projections 32.0 to 36.0 microns; breadth of equatorial projections 14.0 to 16.0 microns.

HOLOTYPE DIMENSIONS: Polar axis 36.8 microns; equatorial axis 17.6 microns; distance from the center of polar axis to the tips of equatorial projections 36.0 microns; breadth of equatorial projections 16.0 microns.

HOLOTYPE PREPARATION: DH 4/2 : 38.2/115.8, Pl. XVII, Fig. 6.

ILLUSTRATED SPECIMENS: DH 4/2 : 35.6/120.0, Pl. XVII, Figs. 4, 5; DH 4/1 : 42.2/111.3, Pl. XVII, Fig. 7.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Heteropolarity, long equatorial projections, reticulate ornamentation on the "neck" of polar projections are the distinguishing characters of A. paplionis.

NAME DERIVATION: Latin paplionis = butterfly.

Aquilapollenites petasus n. sp.

Plate XVIII, Figures 1-3.

1961 Taurocephalus proteus Simpson (pars); Trans. Roy. Soc. Edin., vol. 64, no. 16, p. 440, pl. 12, fig. 11, (non figs. 1-8, 10).

DESCRIPTION: Pollen grain with four equatorially situated apical projections and with one projection each on the proximal and distal polar region; isopolar, polar projections round, short, equatorial projections well developed, long, meridional development slight, well developed equatorially, apices round in equatorial view, pointed in polar view; pollen-body well developed equatorially, in polar view equatorial area rhombical with equatorial projection on each corner; tetracolpate, colpi long, reaching polar projections, meridional across equatorial projections; sexine tectate, baculate, echinate, thicker at polar projections and meridionally along margins of the colpi, ornamentation infrareticulate, reticula size less than 1 micron, large and acuminate spinules, densely distributed on polar projections; short and blunt spinules sparsely distributed on rest of pollen-body, breadth of larger spinules at base about 1.5 microns, length 2.5 microns; breadth of smaller spinules at base about 1.5 microns, length 1 to 1.5 microns.

HOLOTYPE DIMENSIONS: Polar axis about 20.0 microns; equatorial axis 36.0 microns; distance from the center of polar axis to the tips of equatorial projections 46.4 microns.

HOLOTYPE PREPARATION: DH 13/1 : 41.6/113.4, Pl. XVIII, Figs. 1-3.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Thinner sexine, rhombical equatorial area and long equatorial projections distinguish A. petasus from A. stellatus.

One of the specimens of Taurocephalus proteus Simpson from Mull of Argyllshire, western Scotland, illustrated by Simpson (1961) has four equatorial projections and is similar to A. petasus. Simpson (1961) included three or four types of pollen in T. proteus which is evident from his illustrations. Albertan specimens have been recorded from the lower part of the Edmonton Formation which belongs to Maestrichtian Age. The significance of similar pollen in Tertiary pollen flora of Mull and Ardnamurchan is discussed in Chapter VII.

NAME DERIVATION: Latin petasus = a broad brimmed hat.

Aquilapollenites pudicus n. sp.

Plate XVIII, Figure 4.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; subisopolar, polar projections narrow, well developed, one polar projection broader, poles flat and round, the other polar projection smaller; equatorial projections meridional, long, broad, base very wide at the contact with pollen-body, almost covering whole polar axis leaving small portion of polar projections; tricolpate, colpi meridional across the apices of equatorial projections, restricted within apical region; sexine echinate, thickens meridionally extending over equatorial projections, spinules more dense on polar projections, tips of spinules on equatorial projections directed towards the body.

HOLOTYPE DIMENSIONS: Polar axis 35.2 microns; equatorial

axis 12.0 microns; distance from the center of polar axis to the tips of equatorial projections 24.8 microns; maximum breadth of equatorial projection 16.0 microns.

HOLOTYPE PREPARATION: DH 42/1 : 46.6/124.7, Pl. XVIII, Fig. 4.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Narrow polar projections, larger and broader equatorial projections and larger size of spinules distinguish A. pudicus from A. pumilis.

NAME DERIVATION: Latin pudicus = modest.

Aquilapollenites pumilis n. sp.

Plate XVIII, Figure 5.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; subisopolar, polar projections well developed and equal in length, one polar projection broader, flat and round, other polar projection bluntly conical; equatorial projections well developed, meridional, broad; tricolpate, colpi meridional across the apices of equatorial projections, restricted in apical region; sexine echinate, thickens meridionally along the contact of polar and equatorial projections, sexine thickening extends up to the apical region of equatorial projections, maximum width of thickened area 4 microns in equatorial view, sexine thin in apical regions and equatorial regions of pollen-body, densely echinate at polar projections.

HOLOTYPE DIMENSIONS: Polar axis 32.0 microns; equatorial axis 16.0 microns, distance from the center of the polar axis to the tips of equatorial projections 16.0 microns; maximum breadth of apical region of equatorial projections 12.8 microns.

HOLOTYPE PREPARATION: DH 42/1 : 27.2/123.8, Pl. XVIII, Fig. 5.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Broad and short equatorial projections and echinate sexine are the distinguishing characters of A. pumilis.

NAME DERIVATION: Latin pumilis = dwarfed, little, diminutive.

Aquilapollenites regalis n. sp.

Plate XVIII, Figures 6, 7.

1961 Taurocephalus proteus Simpson (pars), Trans. Roy. Soc. Edin. vol. 64, no. 16, p. 440, pl. 12, figs. 2, 3, 4, 8 (non 1, 5-7, 10, 11).

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; isopolar, polar projections well developed, elongate, round; equatorial projections, long, well developed, equatorial in position, equatorial projections projected about 16 microns from the equatorial bulge of pollen-body, apices round; tricolpate, colpi meridional across the apices of equatorial projections, long, extend up to polar projections on both sides; sexine pilate, thicker at polar projections and apical regions of equatorial projections, ornamentation infrareticulate, size of reticula less than 1 micron, spines scattered,

more at polar projections and apical regions of equatorial projections, rare on rest of pollen-body, breadth of spines at base about 2.5 microns, length 3 to 3.5 microns, acuminate, spines smaller at apical region of equatorial projections and curved toward pollen-body.

HOLOTYPE DIMENSIONS: Polar axis 40.0 microns; equatorial axis 44.0 microns; distance from the center of the polar axis to the tips of equatorial projections 44.8 microns; breadth of equatorial projections 14.4 microns at apical regions.

HOLOTYPE PREPARATION: Sc 1-23/1 : 71.2/114.5, Pl. XVIII, Figs. 6, 7.

LOCALITY: Scollard Locality 1, middle division, Edmonton Formation; Maestrichtian.

REMARKS: Shorter polar axis than equatorial axis, equatorial bulge of pollen body, large spines and long colpi are distinguishing characteristics of A. regalis. Simpson (1961) has illustrated two specimens under Taurocephalus proteus from the Tertiary flora of Scotland which are similar to Aquilapollenites regalis. The significance of such pollen on Tertiary flora is discussed in Chapter VII.

NAME DERIVATION: Latin regalis = regal, splendid.

Aquilapollenites sentus n. sp.

Plate XIX, Figures 1-5; Plate XX, Figures 1-5.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; isopolar to subisopolar, polar projections flat to round, well developed, slightly constricted at the base of

projections, equatorial projections meridional, long, broad at the base, becoming considerably narrow at the apices, apices round; pollen-body bulged equatorially; tricolpate, colpi short, meridional across the apices of equatorial projections, restricted within apical region; sexine finely reticulate with scattered spines all over the surface of the pollen-body, sexine meridionally thick and becomes thinner progressively from the base up to apical regions of equatorial projections; reticulations uniform, lumina less than 1 micron, muri thin, thickness less than 1 micron, low, spines large, breadth of spines at base 1.5 to 3.5 microns, length 4 to 7 microns, larger spines confined toward the base of equatorial projections, central portion of equatorial projections free from spines, short curved spines present at apical regions at the margins of colpi, base of spines reticulate, spines formed by the fusion of muri of a few reticula.

SIZE RANGE: Polar axis 47 to 92 microns; equatorial axis 20 to 40 microns; distance from the center of the polar axis to the tips of equatorial projections 22 to 45 microns.

HOLOTYPE DIMENSIONS: Polar axis 92.0 microns; equatorial axis 40.0 microns; distance from the center of the polar axis to the tips of equatorial projections 44.0 microns.

HOLOTYPE PREPARATION: BT 5/2 : 26.2/120.8, Pl. XIX, Figs. 1, 2.

ILLUSTRATED SPECIMENS: BT 5/1 : 53.8/120.3, Pl. XIX, Figs. 3, 4; DH 31/2 : 44.4/115.1, Pl. XIX, Fig. 5; BT 5/1 : 41.5/120.5, Pl. XX, Figs. 1, 2; DH 6/1 : 45.0/124.9, Pl. XX, Figs. 3-5.

LOCALITY: East Coulee Locality, Drumheller Locality, Horseshoe Canyon Locality, Betty Tolman Locality and Scollard Locality 1,

lower and middle divisions, Edmonton Formation; Maestrichtian.

REMARKS: Aquilapollenites sentus can be distinguished from other similar species by large and sturdy spines, short colpi, elongate shape and larger size of pollen.

NAME DERIVATION: Latin sentus = thorny.

Aquilapollenites stellatus n. sp.

Plate XXI, Figures 1, 2.

DESCRIPTION: Pollen grains with four equatorially situated apical projections and with one projection each on the proximal and distal region; heteropolar, one polar projection well developed, round, the other very much reduced; equatorial projections well developed, long, equatorial in position, meridional growth slight, broad at base, narrow at apices, apices round in equatorial view; tetracolpate, colpi medium, meridional across the apices of the equatorial projections up to half the length of equatorial projections; sexine baculate, baculae close together, intectate, thicker at polar projections and meridional areas of equatorial projections; ornamentation infrareticulate, echinate, spinules acuminate, densely distributed at polar projections, extend in distribution meridionally and equatorially in a row of two spinules, thus meridional row of spinules at the margins of colpi and the equatorial row across at right angles to colpi, breadth of spinule bases at polar projections 1.5 microns, length 2.5 microns, straight, breadth of spinule bases on equatorial projections about 1.5 microns, length 1.5 microns, apices of spinules curved toward pollen-body.

HOLOTYPE DIMENSIONS: Polar axis 20.8 microns (?); equatorial

axis 28.0 microns; distance from the center of polar axis to the tips of equatorial projections 34.4 microns; average breadth of equatorial projections 13.6 microns.

HOLOTYPE PREPARATION: DH 39/2 : 27.8/117.7, Pl. XXI, Figs. 1, 2.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: The distribution pattern of spinules, nature of equatorial projections and heteropolarity distinguish A. stellatus from A. petasus.

NAME DERIVATION: Latin stellatus = starry.

Aquilapollenites amplus Stanley 1961

Plate XXI, Figures 3, 4.

1961 Aquilapollenites amplus Stanley; Pollen et Spores, vol. 3, no. 2, p. 342, pl. 1, figs. 1-6; pl. 2, figs. 1-4; pl. 3, figs. 1-5.

SIZE RANGE: Polar axis 44 to 62 microns; equatorial axis 12 to 24 microns; distance from the center of the polar axis to the tips of equatorial projections 30 to 36 microns; breadth of apical regions of equatorial projections 15 to 18 microns.

ILLUSTRATED SPECIMENS: HC 6/2 : 54.8/118.8, Pl. XXI, Figs. 3, 4.

LOCALITY: Horseshoe Canyon Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: A. amplus is subisopolar rather than isopolar as described by Stanley (1961). The specimens of A. amplus illustrated by Stanley (1961) also show subisopolarity.

Aquilapollenites asper Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961

Plate XXI, Figures 5-7.

1961 Aquilapollenites asper Mtchedlishvili in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 213, pl. 68, figs. 2a-c.

ILLUSTRATED SPECIMENS: BT 2/1 : 41/111.2, Pl. XXI, Figs. 5-7.

LOCALITY: Betty Tolman Locality, middle division, Edmonton Formation; Maestrichtian.

SIZE RANGE: Polar axis 47.4 to 58.5 microns (average 51.3 microns); equatorial axis (including the length of two equatorial projections) 56.5 to 57.4 microns (average 56.9 microns); breadth of pollen-body 15.4 to 19.4 microns (average 17.3 microns); length of polar projections 17.1 to 21.1 microns (average 19.3 microns); breadth of equatorial projections 11.8 to 18.9 microns (average 15.5 microns) (Samoilovitch and Mtchedlishvili 1961).

REMARKS: A. asper can be distinguished in having coarse reticula, a well defined pilate layer and long spines on the body. In Siberia, A. asper has been recorded from Maestrichtian to Danian (Samoilovitch and Mtchedlishvili 1961).

Aquilapollenites granulatus Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961.

Plate XXII, Figures 1-4.

1961 Aquilapollenites granulatus Mtchedlishvili in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 212, pl. 68, figs. 1a-c.

SIZE RANGE: Polar axis 45.5 to 51.4 microns (average 48.5

microns); equatorial axis (including the length of two equatorial projections) 46.6 to 57.2 microns (average 54.4 microns); breadth of pollen-body 13.6 to 18.7 microns (average 16.6 microns); length of equatorial projections 15.6 to 21.7 microns (average 19.0 microns); breadth of equatorial projections 13.6 to 16.2 microns (average 15.0 microns) (Samoilovitch and Mtchedlishvili 1961).

ILLUSTRATED SPECIMENS: BT 6/1 : 39.0/115.1, Pl. XXII, Figs. 1, 2; DH 24/1 : 64.3/117.2, Pl. XXII, Figs. 3, 4.

LOCALITY: Drumheller Locality, Betty Tolman Locality, middle and lower divisions, Edmonton Formation; Maestrichtian.

REMARKS: Large size of pollen, shape of the body and sexine structure distinguish A. granulatus from other similar species. The geologic range of A. granulatus, given by Samoilovitch and Mtchedlishvili (1961) is Maestrichtian to Danian.

Aquilapollenites insignis Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961

Plate XXII, Figures 5, 6.

1961 Aquilapollenites insignis Mtchedlishvili in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 215, pl. 68, figs. 1a-c, 2, 3.

SIZE RANGE: Polar axis 45.3 to 46.8 microns (average 45.9 microns); equatorial axis (including the length of two equatorial projections) 68.4 to 69.0 microns (average 68.7 microns); breadth of body 12.6 to 15.1 microns (average 13.7 microns); length of equatorial projections 27.7 to 28.2 microns (average 28.0 microns); breadth of equatorial projections 15.4 to 15.8 microns (average 15.6 microns) (Samoilovitch and Mtchedlishvili 1961).

ILLUSTRATED SPECIMENS: DH 24/1 : 58.8/117.8, Pl. XXII, Figs. 5, 6.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Long and narrow equatorial projections distinguish A. insignis from other similar species. A. insignis has been recorded from lower Maestrichtian of Siberia (Samoilovitch and Mtchedlishvili 1961).

Aquilapollenites polaris Funkhouser 1961

Plate XXIII, Figures 1-4.

1961 Aquilapollenites polaris Funkhouser; Micropaleontology, vol. 7, no. 2, p. 198, pl. 1, figs. 1, 2.

SIZE RANGE: Polar axis 28 to 35 microns; equatorial axis 18 to 20 microns; distance from the center of polar axis to the tips of equatorial projections 18 to 25 microns; breadth of apical region of equatorial projections 11 to 14 microns.

ILLUSTRATED SPECIMENS: BT 2/1 : 60.8/125.0, Pl. XXIII, Figs. 1, 2; Sc 1-24/1 : 40/125, Pl. XXIII, Fig. 3; Sc 1-24/1 : 63/116.7, Pl. XXIII, Fig. 4.

LOCALITY: Betty Tolman Locality, Scollard Locality 1, middle division, Edmonton Formation; Maestrichtian.

REMARKS: Funkhouser (1961) described A. polaris as tridemicolpate. A closer study of such pollen recovered in Alberta suggests that A. polaris has three short meridional colpi at the apices of the equatorial projections rather than demicolpi in thickened sexinal areas of the equatorial projections.

Aquilapollenites spinulosus Funkhouser 1961

Plate XXIII, Figures 5, 6.

1961 Aquilapollenites spinulosus Funkhouser; Micropaleontology, vol. 7, no. 2, p. 194, pl. 1, figs. 4-6.

SIZE RANGE: Polar axis 30 to 35 microns; equatorial axis 10 to 14 microns; distance from the center of polar axis to the tips of equatorial projections 15 to 20 microns; breadth of apical regions of equatorial projections 10 to 12 microns.

ILLUSTRATED SPECIMENS: HC 6/2 : 46.1/126.8, Pl. XXIII, Figs. 5, 6.

LOCALITY: Horseshoe Canyon Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: A. spinulosus is subisopolar and has three meridional colpi across the apices of equatorial projections. It is not isopolar and demicolpi do not exist in the sexinal thickenings of equatorial projections as described by Funkhouser (1961). A. spinulosus illustrated by Funkhouser (1961) also shows subisopolarity. Alberta specimens distinctly show apical meridional colpi (Pl. XXIII, Fig. 5).

Aquilapollenites decorus n. sp.

Plate XXIII, Figures 7-12.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; isopolar to slightly subisopolar, polar projections small, round, one polar projection slightly narrower and shorter than the other; equatorial projections well developed, meridional,

arising almost from the poles, width of base almost equal to polar axis, apices broadly round; tricolpate, colpi long, meridional across the apices extending 3/4 length of equatorial projections on either sides; sexine tectate, baculate, thickens meridionally at the contact of equatorial and polar projections, sexine thinner and more compact at polar projections, ornamentation infrareticulate, size about 1 micron, sexine intectate in some portions.

HOLOTYPE DIMENSIONS: Polar axis 28.0 microns; equatorial axis 16.0 microns; distance from the center of the polar axis to the tips of equatorial projections 16.0 microns.

HOLOTYPE PREPARATION: DH 35/1 : 67.2/124.0, Pl. XXIII, Figs. 7, 8.

ILLUSTRATED SPECIMENS: DH 4/1 : 56.9/125.0, Pl. XXIII, Fig. 9; DH 4/1 : 51.9/122.9, Pl. XXIII, Fig. 10; DH 4/1 : 64.8/121.0, Pl. XXIII, Fig. 11; DH 29/1 : 50.0/124.9, Pl. XXIII, Fig. 12.

LOCALITY: Drumheller Locality, East Coulee Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: A. decorus has tectate sexine with reticulate ornamentation, smaller size and very broad equatorial projections to distinguish it from other similar species.

NAME DERIVATION: Latin decorus = seemly, beautiful, suitable.

Aquilapollenites amicus n. sp.

Plate XXIV, Figures 1, 2.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; isopolar, poles round; equatorial projections small,

round, auriculate; tricolporate, colpi meridional across the equatorial projections, long, reaching polar regions, pores elongate across meridional colpi at the equatorial axis; sexine pilate, pila 0.5 to 0.8 micron wide, 1 to 1.5 microns high; ornamentation on body and equatorial projections retipilate, mesh size less than 1 micron.

HOLOTYPE DIMENSIONS: Polar axis 33 microns; equatorial axis 31 microns; distance from the center of the polar axis to the tips of equatorial projections 20.0 microns; maximum breadth of equatorial projections 9.6 microns.

HOLOTYPE PREPARATION: DH 42/1 : 27.8/115.7, Pl. XXIV, Figs. 1, 2.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Retipilate ornamentation and tricolporate character of pollen distinguishes A. amicus from other similar species of Aquilapollenites.

NAME DERIVATION: Latin amicus = friendly.

Aquilapollenites amygdaloides n. sp.

Plate XXIV, Figures 3-5.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; slightly subisopolar, one pole conical and the other flattened; body almond-shaped, equatorial area bulged; equatorial projections long, lanceolate; tricolpate, colpi meridional across equatorial projections, long, almost reaching polar regions; sexine

pilate, thinner at the equatorial projections; ornamentation on the body and equatorial projections retipilate, lumina size about 1.5 microns.

HOLOTYPE DIMENSIONS: Polar axis 43.5 microns; equatorial axis 29.0 microns; distance from the center of the polar axis to the tips of equatorial projections 29.0 microns; maximum breadth of equatorial projections 6.5 microns.

HOLOTYPE PREPARATION: DH 40/2 : 26.5/117.7, Pl. XXIV, Figs. 3-5.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: A. amygdaloides differs from other species in having long lanceolate equatorial projections with retipilate ornamentation. A. trialatus Rouse has laevigate equatorial projections and fine reticulate ornamentation on the body. A. chlonovae n. name has very coarse reticulations with thick muri and equatorial colpi.

NAME DERIVATION: Latin Amygdalum = an almond.

Aquilapollenites antigonei n. sp.

Plate XXIV, Figure 6.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region; isopolar, polar projections round; equatorial projections long, apices broad and flat, base oriented along equatorial axis; tricolpate, colpi meridional across equatorial projections, long, reaching polar regions; sexine double layered,

outer-layer thin, pilate, pila 1 micron broad and 1 micron high, inner-layer smooth, thick, thin toward the apices of equatorial projections; ornamentation retipilate, mesh size about 1 micron.

HOLOTYPE DIMENSIONS: Polar axis 38.0 microns; equatorial axis 31.2 microns; distance from the center of the polar axis to the tips of equatorial projections 28.0 microns; maximum breadth of equatorial projections 13.6 microns.

HOLOTYPE PREPARATION: DH 42/1 : 34.0/114.5, Pl. XXIV, Fig. 6.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Retipilate ornamentation on pollen-body and equatorial projections and equatorially oriented long and broad equatorial projections distinguish A. antigonei from other similar species of Aquilapollenites.

NAME DERIVATION: The specific epithet is after the ancient Greek character Antigone.

Aquilapollenites catenireticulatus n. sp.

Plate XXIV, Figures 7-9.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on proximal and distal polar region; subisopolar, polar projections small, round at poles; equatorial projections auriculate, continuous with polar projections; tricolpate, colpi meridional across equatorial projections, long, reaching polar regions; sexine bastionate; ornamentation reticulate,

mesh size variable - larger on body and smaller on equatorial projections.

HOLOTYPE DIMENSIONS: Polar axis 35.2 microns; equatorial axis 22 microns; distance from the center of polar axis to the tip of equatorial projections 18.6 microns.

HOLOTYPE PREPARATION: EC 1A/2 : 46.6/127.3, Pl. XXIV, Figs. 7-9.

LOCALITY: East Coulee Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Tricolpate, reticulate ornamentation on body as well as on auriculate equatorial projections distinguish A. catenireticulatus from other similar species. A. triauritus Takahashi is tridemicolpate.

NAME DERIVATION: The specific epithet is given for the chain-like reticulations on the pollen body (Latin catena = chain).

Aquilapollenites ceriocorpus n. sp.

Plate XXV, Figures 1-4.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on proximal and distal polar region; subisopolar, one polar projection conical and the other flattened; equatorial projections long, almost rectangular with flat apices, a slight meridional elevation continues from the equatorial projections toward both the poles; tricolpate, colpi meridional across equatorial projections, long, reaching polar regions; sexine thick on body, thin on equatorial projections; sexine bastionate, ornamentation reticulate, muri thicker (0.5 micron approximately) and higher on body, thinner and flat on equatorial projections, lumina size 1 to 3 microns,

larger lumina on the central portion of body, smaller toward the base of equatorial projections and on polar regions.

HOLOTYPE DIMENSIONS: Polar axis 52.8 microns; equatorial axis 33.6 microns; distance from the center of polar axis to the tips of equatorial projections 29.6 microns; equatorial projections about 14.4 microns wide at the base.

HOLOTYPE PREPARATION: HC 5/2 : 45.7/125.0; Pl. XXV, Figs. 1-4.

LOCALITY: Horseshoe Canyon Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: A. ceriocorpus has long equatorial projections with flat apices. It has large reticulations on the central portion of the body, smaller reticulations at the base of equatorial projections and at polar regions. A. reductus Norton has peg-like round equatorial projections with smooth base and reticulate apices. A. funkhouseri Srivastava has reticulate peg-like round equatorial projections and larger reticulations toward polar regions and smaller ones in equatorial region.

NAME DERIVATION: The specific epithet is derived from Latin cerio (= honey-comb) and corpus (= body) for the honey-combed ornamentation on the pollen-body.

Aquilapollenites debilis n. sp.

Plate XXV, Figures 5-7.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on proximal and distal polar region; isopolar, polar projections well developed, long, thinner

than equatorial projections with flat poles; equatorial projections large, broader than polar projections, with round apices; tridemicolpate?, three pairs of demicolpi probably situated at the junction of equatorial and polar projections, extending meridionally from the polar areas to less than half the length of equatorial projections, demicolpi not distinct; sexine pilate, pila distinctly visible on body and polar projections, sexine thin on outer margin of the equatorial projections, a band of thicker sexine about 2 microns wide runs parallel and about 2.5 to 3.5 microns inside the meridional margin of equatorial projections; ornamentation retipilate, mesh size about 1 micron, finer at the margins of equatorial projections on external side of the thicker sexine band.

HOLOTYPE DIMENSIONS: Polar axis 41.6 microns; equatorial axis 12.8 microns; distance from the center of polar axis to the tip of equatorial projections 17.6 microns; maximum breadth of equatorial projections 18.4 microns.

HOLOTYPE PREPARATION: EC 7/4 : 47.2/120.8, Pl. XXV, Figs. 5-7.

LOCALITY: East Coulee Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: A band of thicker sexine on equatorial projections, retipilate ornamentation and tridemicolpate nature of pollen distinguish A. debilis from other species of Aquilapollenites.

NAME DERIVATION: Latin debilis = weak, feeble.

Aquilapollenites leucocephalus n. sp.

Plate XXVI, Figures 1-5.

DESCRIPTION: Pollen grains with three equatorially situated

projections and with one projection each on proximal and distal polar regions; subisopolar, one pole more flattened than the other; equatorial projections small, round, peg-like; tricolpate, colpi meridional across equatorial projections, long, reaching subpolar regions; ornamentation reticulate all over the body and equatorial projections except on polar regions; polar regions smooth, smooth area 5 to 10 microns in radius, reticulations large about 1.5 to 2.5 microns between the smooth polar region and the equatorial region, equatorial region about 15 to 18 microns wide, bulged and having small reticulations of 0.5 to 1.5 microns wide, bulged and having small reticulations of 0.5 to 1.5 microns size, equatorial projections reticulate with mesh size of about 0.5 to 1 micron.

SIZE RANGE: Polar axis 45.0 to 64.0 microns; equatorial axis 22.0 to 34.0 microns; distance from the center of polar axis to the tips of equatorial projections 29.0 microns; equatorial projections 11 x 11 microns; radius of smooth area on poles 4.0 to 9.0 microns.

HOLOTYPE DIMENSIONS: Polar axis 64.0 microns; equatorial axis 34.0 microns; distance from the center of polar axis to the tips of equatorial projections 29.0 microns; equatorial projections 11 x 11 microns; radius of smooth area on poles 7.0 microns.

HOLOTYPE PREPARATION: EC 7/4 : 68.9/117.3, Pl. XXVI, Figs. 1-5.

LOCALITY: East Coulee Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Small, finely reticulate equatorial projections, bulged equatorial area with fine reticulations, and smooth polar areas are the distinguishing characteristics of A. leucocephalus.

NAME DERIVATION: The species name of the "Bald Eagle"

(American Eagle) is Haliacetus leucocephalus. The specific epithet of A. leucocephalus is chosen here in connotation of the "bald" areas on both poles.

Aquilapollenites medeis n. sp.

Plate XXVI, Figure 6; Plate XXVII, Figures 1, 2.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on proximal and distal polar regions; subisopolar, one pole broad and flat, other pole narrow and round; equatorial projections lanceolate, long; meridional colpi three across equatorial projections, long, narrow, reaching polar regions, equatorial colpi three, short, narrow, restricted within equatorial projections; sexine bastionate, thin on equatorial projections; ornamentation reticulate, lumina larger on polar regions, smaller on equatorial region, lumina size up to 3.5 microns, muri thickness about 1 to 1.5 microns, height about 2.5 microns, equatorial projections faintly reticulate.

SIZE RANGE: Polar axis 40.0 to 43.2 microns; equatorial axis 25.6 to 32.0 microns; distance from the center of polar axis to the tips of equatorial projections 24.4 to 28.0 microns; maximum breadth of equatorial projections 7.2 to 8.8 microns.

HOLOTYPE DIMENSIONS: Polar axis 43.2 microns; equatorial axis 25.6 microns; distance from the center of polar axis to the tips of equatorial projections 24.4 microns; maximum breadth of equatorial projections 7.2 microns.

HOLOTYPE PREPARATION: MB 1/2 : 26.6/114.2; Pl. XXVI, Fig. 6; Pl. XXVII, Figs. 1, 2.

LOCALITY: Morrin Bridge Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Equatorial colpi, high muri and large reticulations, lanceolate and faintly reticulate equatorial projections distinguish A. medeis from A. funkhouseri and A. reductus.

NAME DERIVATION: Latin medeis = magical.

Aquilapollenites mirabilis n. sp.

Plate XXVII, Figures 3-8.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on proximal and distal polar regions; subisopolar, one pole more flattened than the other, poles round; equatorial projections short, spatulate; tricolpate, colpi meridional across equatorial projections; sexine bastionate ornamentation reticulate, lumina size 1.5 to 2.5 microns, smaller on the equatorial region, larger on polar regions, muri thickness 0.5 to 0.8 micron, height about 2.5 microns in equatorial region, height 0.8 to 1.0 micron at poles, basal portion of equatorial projections striate, striae start from the base of equatorial projections and fan out over margins, broader apical part of equatorial projections reticulate, lumina size about 1.5 microns.

SIZE RANGE: Polar axis 53.6 microns; equatorial axis 20.0 to 41.6 microns; distance from the center of polar axis to the tips of equatorial projections 22.4 to 32.0 microns; maximum breadth of equatorial projections 8.8 to 12.0 microns.

HOLOTYPE DIMENSIONS: Polar axis 53.6 microns; equatorial

axis 41.6 microns; distance from the center of polar axis to the tips of equatorial projections 28.0 microns; maximum breadth of equatorial projections about 10.0 microns.

HOLOTYPE PREPARATION: EC 7/4 : 43.0/120.6; Pl. XXVII, Figs. 6-8.

ILLUSTRATED SPECIMENS: EC 1A/2 : 67.3/127.0; Pl. XXVII, Figs. 3-5.

LOCALITY: East Coulee Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: A. mirabilis can be distinguished by large reticulations on polar regions, and spatulate equatorial projections with striate bases. Striae on the equatorial projections run halfway from base towards the apex.

NAME DERIVATION: Latin mirabilis = wonderful, marvelous.

Aquilapollenites oblatus n. sp.

Plate XXVIII, Figures 1-6.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on proximal and distal polar regions; slightly subisopolar, one pole more flattened than the other; equatorial projections small, round, peg-shaped; three meridional colpi across equatorial projections, long, reaching polar areas; three equatorial colpi, transecting the meridional colpi and equatorial projections, restricted within equatorial projections, reaching margin of the body; body ornamentation reticulate, lumina size 0.5 to 0.8 micron, muri thickness about 0.5 micron, raised, sexine thin on equatorial projections; ornamentation on equatorial projections reticulate, muri thin and flat, reticula arranged linearly, emerging from the base of

equatorial projections and fanning out to the margin of equatorial projections.

SIZE RANGE: Polar axis 32.0 to 44.0 microns; equatorial axis 20.0 to 33.6 microns; distance from the center of polar axis to the tips of equatorial projections 16.8 to 26.4 microns; maximum breadth of equatorial projections 8.8 to 12.0 microns.

HOLOTYPE DIMENSIONS: Polar axis 35.0 microns; equatorial axis 31.6 microns; distance from the center of polar axis to the tips of equatorial projections 21.6 microns; maximum breadth of equatorial projections 8.8 microns.

HOLOTYPE PREPARATION: DH 39/1 : 63.8/110.6, Pl. XXVIII, Figs. 3-5.

ILLUSTRATED SPECIMENS: DH 40/2 : 60.0/119.1, Pl. XVIII, Figs. 1, 2; DH 39/2 : 48.5/122.0, Pl. XXVIII, Fig. 6.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: A. oblatus differs from A. reticulatus Stanley by the presence of three meridional and three equatorial colpi. A. reticulatus Stanley has only three pairs of meridional demicolpi, and a different shape of body.

NAME DERIVATION: Latin oblatus = flattened base.

Aquilapollenites stelckii n. sp.

Plate XXVIII, Figures 7-9.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on proximal and distal

polar regions; subisopolar, poles slightly flattened, polar projections well developed; body more or less rectangular; equatorial projections large, width almost equal throughout, apices round; colpi not clear, only a suggestion of three pairs of demicolpi at the margins of equatorial projections; sexine pilate, thin on equatorial projections; ornamentation retipilate, retipilation strong on polar projections, faint on equatorial projections and on central part of body, reticula linearly arranged parallel to polar axis on the central part of body and equatorial projections.

HOLOTYPE DIMENSIONS: Polar axis 35.2 microns; equatorial axis 12.4 microns; distance from the center of polar axis to the tips of equatorial projections 18.6 microns; maximum breadth of equatorial projections 10.4 microns.

HOLOTYPE PREPARATION: EC 1/2 : 49.7/125.1, Pl. XXVIII, Figs. 7-9.

LOCALITY: East Coulee Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Large equatorial projections with linearly arranged reticulations, tridemicolpate pollen and rectangular body distinguish A. stelckii from other species of Aquilapollenites.

NAME DERIVATION: The specific epithet is named in honor of Professor C. R. Stelck, Department of Geology, University of Alberta, Edmonton (Canada).

Aquilapollenites validus n. sp.

Plate XXVIII, Figures 10, 11; Plate XXIX, Figure 1.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on proximal and distal polar regions; slightly subisopolar, one polar projection thinner than the other; equatorial projections small with blunt apices, base constricted; three meridional colpi across equatorial projections, long, reaching polar regions; three equatorial colpi, short, restricted within the equatorial projections, reaching the body; sexine pilate, pila height about 1 micron; ornamentation retipilate, lumina size about 0.8 micron, muri formed by fusing of pila, thickness of muri 0.5 to 0.8 micron, sexine slightly thinner near the apices of equatorial projections, pila arranged linearly on equatorial projections, running from the margins of equatorial colpi to the margins of equatorial projections.

SIZE RANGE: Polar axis 38.4 to 41.6 microns; equatorial axis 19.2 to 28.0 microns; distance from the center of polar axis to the tips of equatorial projections 16.0 to 23.2 microns; maximum breadth of equatorial projections 8.0 to 12.0 microns.

HOLOTYPE DIMENSIONS: Polar axis 41.6 microns; equatorial axis 28.0 microns; distance from the center of polar axis to the tips of equatorial projections 22.4 microns; maximum breadth of equatorial projections 8.0 microns.

HOLOTYPE PREPARATION: DH 42/2 : 54.3/120.9, Pl. XXVIII, Figs. 10, 11; Pl. XXIX, Fig. 1.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: A. validus differs from A. oblatus in having retipilate ornamentation, and from A. mtchedlishviliae in having equatorial colpi.

NAME DERIVATION: Latin validus = strong, stout, powerful.

Aquilapollenites venustus n. sp.

Plate XXIX, Figures 2-6.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and one projection each on proximal and distal polar regions; isopolar, poles round; equatorial projections small, apices round; tricolpate, colpi meridional across equatorial projections, long, extending up to polar regions; sexine pilate, pila thickness about 0.8 micron, height 1 micron, sexine thin on equatorial projections; ornamentation on body retipilate, reticula size 0.5 micron, equatorial projections faintly reticulate.

SIZE RANGE: Polar axis 35.2 to 38.4 microns; equatorial axis 21.6 to 28.8 microns; distance from the center of polar axis to the tips of equatorial projections 19.2 to 23.2 microns; maximum breadth of equatorial projections 6.4 to 12.0 microns.

HOLOTYPE DIMENSIONS: Polar axis 36.4 microns; equatorial axis 28.0 microns; distance from the center of polar axis to the tips of equatorial projections 12.0 microns.

HOLOTYPE PREPARATION: EC 8/1 : 67.6/118.7, Pl. XXIX, Figs. 2-4.

ILLUSTRATED SPECIMENS: DH 39/2 : 26.6/115.8, Pl. XXIX, Figs. 5, 6.

LOCALITY: East Coulee Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: The presence of retipilate ornamentation and small reticulations (about 0.5 micron) distinguish A. venustus from A. mirabilis and A. ceriocorpus.

NAME DERIVATION: Latin venustus = charming, lovely, graceful.

Aquilapollenites dolium (Samoilovitch) n. comb.

Plate XXIX, Figures 7-9.

1965 Parviprojectus dolium Samoilovitch; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 239, pl. 3, figs. 1-3, t. figs. 7-9.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and one projection each on proximal and distal polar regions; slightly subisopolar, polar projections not well developed, one pole slightly flattened; equatorial projections very small, round in outline, equatorially flattened; tricolpate, colpi meridional across equatorial projections, long, narrow, reaching subpolar regions; sexine pilate, pila small, thickness about 1 micron and height 1 micron, sexine slightly thinner on equatorial projections; ornamentation retipilate on body and equatorial projections.

SIZE RANGE: Polar axis 29.6 to 30.4 microns; equatorial axis 25.6 to 29.6 microns; distance from the center of polar axis to the tip of equatorial projections 14.4 to 16.8 microns;length of equatorial projections 4 microns; breadth of equatorial projections 5.6 microns.

Measurements given by Samoilovitch (1965): Polar axis 25.5 to 31.7 microns, more often 31.0 microns; equatorial axis (with

equatorial projections) 26.5 to 28.0 microns, more often 27.0 microns; breadth of the body of pollen grain 17.0 to 22.3 microns, more often 17.5 microns; length of equatorial projections 2.2 to 6.4 microns, more often 3.0 microns; breadth of equatorial projections 4.5 to 7.0 microns, more often 5.0 microns.

ILLUSTRATED SPECIMENS: DH 39/1 : 60.9/123.4, Pl. XXIX, Figs. 7-9.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Very small equatorial projections, retipilate ornamentation, oblate shape of body, and tricolpate nature of pollen distinguish A. dolium from other species of Aquilapollenites. Siberian specimens range from Senonian to Danian (Samoilovitch 1965).

Alberta specimens of A. dolium are well within the size range of Siberian specimens (Samoilovitch 1965).

Aquilapollenites funkhouseri Srivastava 1966

Plate XXIX, Figures 10, 11; Plate XXX, Figures 1-3.

SIZE RANGE: Polar axis 36.8 to 48.0 microns; equatorial axis 27.2 to 31.0 microns; distance from the center of polar axis to the tips of equatorial projections 20.0 to 23.2 microns; maximum breadth of equatorial projections 8.0 microns.

ILLUSTRATED SPECIMENS: MB 7/2 : 37.9/111.6, Pl. XXIX,

Figs. 10, 11; Sc 1-24/1 : 28.2/128.3, Pl. XXX, Figs. 1-3.

LOCALITY: Morrin Bridge Locality, Scollard Locality 1, lower and middle divisions, Edmonton Formation; Maestrichtian.

REMARKS: The punctate base and serrate margin of equatorial projections, smaller reticulations on equatorial region and larger in subpolar regions of pollen-body are the distinguishing characteristics of A. funkhouseri.

Aquilapollenites reductus Norton 1965

Plate XXX, Figures 4-7.

1965 Aquilapollenites reductus Norton; Pollen et Spores, vol. 7, no. 1, p. 140, pls. 2, 3, figs. 5-9.

SIZE RANGE: Polar axis 49.6 microns; equatorial axis 27.2 microns; distance from the center of polar axis to the tips of equatorial projections 20.8 microns; maximum breadth of equatorial projections 12 microns.

The measurements given by Norton (1965): Polar axis 44 to 51 microns; equatorial axis 25 microns; distance from the cen center of polar axis to the tips of equatorial projections 16 to 20 microns.

ILLUSTRATED SPECIMENS: DH 38/2 : 31.3/113.9, Pl. XXX,

Figs. 4-7.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: A. reductus has larger reticulations on equatorial region than on polar regions and has psilate proximal ends of equatorial projections.

Aquilapollenites vinosus n. sp.

Plate XXXI, Figures 1-4.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on proximal and distal polar regions; isopolar to slightly subisopolar, polar projections well developed, elongate, narrow and round at poles, equatorial projections well developed, elongate, tubular, arising both meridionally and equatorially, apices narrower than base, round; tricolpate, colpi long, meridional across the apices of equatorial projections, extend from pole to pole; sexine tectate, bastionate, simplibaculate; ornamentation on polar projections reticulate, reticula size about 1 to 1.5 microns, muri high, thickness of muri about 0.8 micron, ornamentation on equatorial projections striate, striae circumambulate the equatorial projections, ornamentation on equatorial region of pollen body is also striate, striae simplibaculate.

HOLOTYPE DIMENSIONS: Polar axis 72.8 microns; equatorial axis 29.6 microns; distance from the center of polar axis to the tips of equatorial projections 32.0 microns; average breadth of equatorial projections 7.2 microns.

HOLOTYPE PREPARATION: BT 30/1 : 66.4/122.0, Pl. XXXI, Figs. 1-4.

LOCALITY: Betty Tolman Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: A. vinosus can be distinguished from A. reticulatus Stanley in being tricolpate and larger in size.

NAME DERIVATION: Latin vinosus = full of wine.

Aquilapollenites alveolatus Jardine and Magloire 1965

Plate XXXI, Figures 5, 6.

1965 Aquilapollenites alveolatus Jardine and Magloire; Mém. Bur. Rech. Géol. Miniéres, no. 32, p. 209, pl. 9, fig. 37.

ILLUSTRATED SPECIMENS: DH 42/1 : 43.7/117.6, Pl. XXXI, Figs. 5, 6.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: A. alveolatus is isopolar, small, broad, tridemi-colpate with thin sexine having regular, round polygonal reticulations.

Aquilapollenites minutus Srivastava 1966

Plate XXXI, Figure 7.

1966 Aquilapollenites minutus Srivastava; Pollen et Spores, vol. 8, no. 3, p. 542, pl. 10, figs. 2, 3.

ILLUSTRATED SPECIMENS: MB 1/1 : 52.2/119.8, Pl. XXXI, Fig. 7.

LOCALITY: Morrin Bridge Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Thin and psilate sexine and small size of pollen distinguish A. minutus from other species of Aquilapollenites.

Aquilapollenites conatus Norton 1965

Plate XXXII, Figures 1-4.

1965 Aquilapollenites conatus Norton; Pollen et Spores, vol. 7, no. 1, p. 142, pl. 3, figs. 10, 11; pl. 4, figs. 12-16.

1966 Aquilapollenites conatus Norton, in Srivastava, Pollen et Spores, vol. 8, no. 3, p. 541, pl. 9, figs. 11-13.

ILLUSTRATED SPECIMENS: Sc 2-B/4 : 46.9/126.0, Pl. XXXII, Figs. 1, 2; Sc 2-B/3 : 67.5/125.0, Pl. XXXII, Figs. 3, 4.

LOCALITY: Scollard Locality 2, upper division, Edmonton Formation; Maestrichtian.

REMARKS: The triangular prismatic shape in polar view, bertillon sculpture of body and the reduced sculpture of equatorial projections distinguish A. conatus from similar forms.

Aquilapollenites macgregorii Srivastava 1966

Plate XXXII, Figures 5.

1966 Aquilapollenites macgregori Srivastava, Pollen et Spores, vol. 8, no. 3, p. 541, figs. 9, 15, 16.

ILLUSTRATED SPECIMENS: EC 5/1 : 44.3/121.9, Pl. XXXII, Fig. 5.

LOCALITY: East Coulee Locality, Scollard Locality 1, lower and middle divisions, Edmonton Formation; Maestrichtian.

REMARKS: Small size of pollen, short polar projections and well developed equatorial projections distinguish A. macgregorii from similar forms.

Genus Mancicorpus Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961, emend.

1961 Mancicorpus Mtchedlishvili in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 218.

TYPE SPECIES: Mancicorpus anchoriforme Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961.

DIAGNOSIS: Pollen grains heteropolar; tricolpate; polar

projection developed on one pole only, on the other side of equatorial axis either polar projection is absent or developed into a small "tubercle", the length of the undeveloped pole from the center of equatorial axis to the tip of the pole is less than half the length of developed polar projection from the center of equatorial axis to the tip of that pole; body cylindrical with round ends, conical, or truncated conical; equatorial projections form a right or an obtuse angle at the junction with the body, or the angle may be absent and the line of junction may be slightly convex; equatorial projections long or short, broad or somewhat narrow, flattened in polar plane; colpi narrow, long, sometimes apparently curved, becoming wide at ends, sometimes demicolpate; sexine baculate, tegillate, infrareticulate, clavate, or reticulate.

REMARKS: The development of one polar projection on the pollen-body and the reduction of the body on the other side of equatorial axis of pollen distinguishes the genus Mancicorpus from the allied genus Aquilapollenites. Heteropolarity is one of the characteristic features of Aquilapollenites which is attained in variable degrees by its different species. In some pollen one of the poles has been reduced acutely, making it concave at that pole. Even such heteropolar species have been described under the genus Aquilapollenites by many workers. However, Mtchedlishvili (in Samoilovitch and Mtchedlishvili 1961) designated the genus Mancicorpus for pollen with a well developed polar projection on one pole and either without a polar projection on the other pole or with a small "tubercle". The size of the "tubercle" is not defined and this leaves the individual worker to his choice to describe the species arbitrarily either under Aquilapollenites or Mancicorpus.

To circumscribe the genus Mancicorpus and to distinguish it from the genus Aquilapollenites, it is here proposed that the genus Mancicorpus should include only those heteropolar pollen whose length of the reduced pole (distance from the center of the equatorial axis to the tip of the polar projection or polar area) is less than half of the length of the developed polar projection (distance from the center of the equatorial axis to the tip of the developed polar projection). The explanation of such measurements are given in Figure 8. For the sake of precision, the equatorial axis is here defined as a line joining the middle points of the tips of any two fully dilated equatorial projections lying in a natural position. In some pollen, the reduction of a pole may have reached such a degree that the equatorial axis may not pass at all through the pollen-body.

The following species are proposed to be transferred to the genus Mancicorpus Mtchedlishvili in Samoilovitch and Mtchedlishvili emended.

Mancicorpus pulcher (Funkhouser) comb. nov.

1961 Aquilapollenites pulcher Funkhouser; Micropaleontology, vol. 7, no. 2, p. 198, pl. 1, figs. 7a-c.

Mancicorpus pyriformis (Norton) comb. nov.

1965 Aquilapollenites pyriformis Norton; Pollen et Spores, vol. 7, no. 1, p. 136, pl. 1, figs. 1-3; pl. 2, fig. 4.

Mancicorpus striatus (Funkhouser) comb. nov.

1961 Aquilapollenites striatus Funkhouser; Micropaleontology, vol. 7, no. 2, p. 196, pl. 2, fig. 4.

non 1961 Parviprojectus striatus Mtchedlishvili in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst.,

Leningrad, vol. 177, p. 225, pl. 73, figs. 1a-c.

Mancicorpus albertensis n. sp.

Plate XXXIII, Figures 1, 2.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and one projection developed on one of the poles, pollen-body at other pole reduced to produce slight concavity; equatorial projections well developed, meridional, arising from both the polar ends, apices broadly rounded; tricolpate, colpi long, meridional across the apices of equatorial projections, extending almost half the length of equatorial projections on both sides towards the poles; sexine tectate, smooth, thickens meridionally up to apical regions of equatorial projections, sexine thin and infrareticulate in apical regions of equatorial projections; ornamentation infrareticulate.

SIZE RANGE: Polar axis 16.0 to 25.0 microns; equatorial axis 32 to 35 microns; distance from the center of polar axis to the tips of equatorial projections 15.0 to 20.0 microns; apical breadth of equatorial projections 10.0 to 13.0 microns.

HOLOTYPE DIMENSIONS: Polar axis 24.8 microns; equatorial axis 35 microns; distance from the center of polar axis to the tips of equatorial projections 20.0 microns; apical breadth of equatorial projections 12.0 microns.

HOLOTYPE PREPARATION: DH 33/2 : 30/117.3, Pl. XXXIII, Fig. 1.

ILLUSTRATED SPECIMENS: DH 4/1 : 62.4/111.0, Pl. XXXIII, Fig. 2.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Mancicorpus albertensis can be distinguished by its smaller size, psilate surface, broad equatorial projections.

Mancicorpus gibbus n. sp.

Plate XXXIII, Figures 3-5.

DESCRIPTION: Pollen grains with three equatorially situated apical projections, and one projection developed on one of the poles, other pole is more or less flat, developed polar projection round with a blunt conical point at polar end; equatorial projections arise meridionally as well as equatorially, long, tubular, apices round; tricolpate, colpi meridional across the apices of equatorial projections, long, extending half the length of equatorial projections; sexine tectate, baculate, echinate, thick, thickens meridionally up to the apical regions of equatorial projections, spinules small, scattered all over body, dense on equatorial projections, spinule apices directed toward poles; ornamentation infrareticulate.

HOLOTYPE DIMENSIONS: Polar axis 46.4 microns; equatorial axis 48.8 microns; distance from the center of polar axis to the tips of equatorial projections 52.0 microns; breadth of apical regions of equatorial projections 8.8 microns.

HOLOTYPE PREPARATION: Sc 18-24/1 : 58.2/119.0, Pl. XXXIII, Figs. 3-5.

LOCALITY: Scollard Locality 18, middle division, Edmonton Formation; Maestrichtian.

REMARKS: Gibbouse polar projection, meridional and equatorial emanation of long and narrow tubular equatorial projections distinguish M. gibbus from other species of the genus Mancicorpus.

NAME DERIVATION: Latin gibbus = humped.

Mancicorpus borealis n. sp.

Plate XXXIII, Figures 6-8.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and one projection developed on one of the poles, on the other pole a very small tubercle-like polar projection present; heteropolar, the developed polar projection long, round at polar end; equatorial projections long, ± equal to polar projections, meridional, arising from the "neck" portion of polar projection, apices round; tricolpate, colpi short, meridional across the apices of equatorial projections, restricted in apical regions of equatorial projections, sexine tectate, baculate, echinate, thickens meridionally extending up to the apical region of equatorial projections; sexine thin on apical regions and equatorial regions of pollen-body, breadth of spinules at base about 0.8 micron, length 1.5 microns, acuminate, scattered all over body, densely distributed on neck region of polar projections, spinules on equatorial projections have apices directed toward poles, ornamentation infrareticulate.

HOLOTYPE DIMENSIONS: Polar axis 40.0 microns; equatorial axis 16.0 microns; distance from the center of polar axis to the tips of equatorial projections 28.0 microns; breadth of equatorial projections 12.8 microns.

HOLOTYPE PREPARATION: DH 33/2 : 66.4/123.8, Pl. XXXIII, Fig. 8.

ILLUSTRATED SPECIMENS: DH 33/2 : 38/117.0, Pl. XXXIII, Figs. 7, 6.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: The long and narrow "developed pole", tubercle like "reduced pole", equatorial projections similar to "developed polar projection", and echinate sexine, distinguish M. borealis from other similar forms.

NAME DERIVATION: Latin borealis = northern.

Mancicorpus senonicus Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961

Plate XXXIII, Figures 9, 10.

1961 Mancicorpus senonicus Mtchedlishvili in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 224, pl. 72, figs. 2a-c, 3.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on proximal and distal polar region, heteropolar, one polar projection very well developed, long, slightly conical at pole, round, other polar projection very small, like a tubercle, polar area conical; equatorial projections well developed, long, meridional, arising from the neck region of developed polar projection and the polar area of reduced polar projection,

apices round; tricolpate, colpi meridicnal across apices of equatorial projections, extending up to the thickened sexinous region on equatorial projections; sexine tectate, baculate at polar area of developed polar projection and equatorial projections becoming bastionate in the rest of polar projections and central pollen body; ornamentation reticulate on polar projections, muri thickness about 1 micron, lumina size 1.6 microns, ornamentation infrareticulate on equatorial projections.

SIZE RANGE: Polar axis 32.8 microns; equatorial axis 17.6 microns; distance from the center of polar axis to the tips of equatorial projections 24.0 microns; breadth of apical region of equatorial projections 11.2 microns.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

ILLUSTRATED SPECIMENS: DH 35/2 : 66.4/124.1, Pl. XXXIII, Figs. 9, 10.

REMARKS: M. senonicus can be distinguished from other similar species by reticulate ornamentation at polar projections and absence of spinules.

Mancicorpus rostratus n. sp.

Plate XXXIV, Figures 1, 2.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and one projection developed on one of the poles, on other pole only vestigial polar projection present by appearance of a slight bulge; heteropolar, equatorial projections very long, tubular, meridional, arising from polar regions, and extending into narrow

projections with round apices; tricolpate, colpi short, meridional across the apices of equatorial projections; sexine bastionate on polar projections, ornamentation reticulate, muri low forming irregular reticula, on equatorial projections sexine tectate and infrareticulate, reticulations on polar projections and equatorial projections grade into each other, hence reticulations are large at the contact of equatorial projections and polar projections, reticula become elongate toward apices and fade into infrareticulate pattern of apical regions; sexine thickens meridionally extending up to apical regions of equatorial projections, a row of spinules border colpi in apical regions of equatorial projections, breadth of spinule bases about 1.5 microns, length about 1.5 to 2.0 microns, acuminate, apices curved towards poles.

HOLOTYPE DIMENSIONS: Polar axis 44.0 microns; equatorial axis 22.4 microns; distance from the center of polar axis to the tips of equatorial projection 63.0 microns; apical breadth of equatorial projections 12.0 microns.

HOLOTYPE PREPARATION: BT 7/1 : 59.8/112.0, Pl. XXIV, Figs. 1, 2.

LOCALITY: Betty Tolman Locality, middle division, Edmonton Formation; Maestrichtian.

REMARKS: M. rostratus can be distinguished by large reticulate ornamentation, long equatorial projections and spinules restricted at colpi margins only.

NAME DERIVATION: Latin rostratus = curved.

Mancicorpus vancampoi n. sp.

Plate XXXIV, Figures 3, 4.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and one projection developed on one of the poles, the other pole reduced without any suggestion of polar projection, heteropolar, the developed polar projection conical at pole with convex sides, the reduced polar area straight at right angles to polar axis, aligned equatorially with one side of equatorial projections, equatorial projections well developed, long, tubular, meridional, arising from polar tips as low ridges, apices round; tricolpate, colpi long, meridional across the apices of equatorial projections, extending up to thickened sexinous area; sexine baculate, tectate, thickens meridionally extending up to apical regions of equatorial projections, ornamentation infrareticulate, echinate, breadth of spinules at base about 1.5 microns, length 1.5 microns, acuminate, spinule tips in equatorial region curved towards polar projections.

HOLOTYPE DIMENSIONS: Polar axis 56.0 microns; equatorial axis 44.0 microns; distance from the center of polar axis to the tips of equatorial projections 49.6 microns; apical breadth of equatorial projections 12.0 microns.

HOLOTYPE PREPARATION: MB 9/1 : 31.0/117.3, Pl. XXXIV, Figs. 3, 4.

LOCALITY: Morrin Bridge Locality, middle division, Edmonton Formation; Maestrichtian.

REMARKS: M. vancompoi has one developed polar projection and tectate sexine with infrareticulate ornamentation in comparison to

M. rostratus which has well pronounced reticulations on body and a slightly developed area of the other pole.

NAME DERIVATION: The specific epithet is given in honor of Madame Madleine Van Campo, Laberatoire de Palynologie au Muséum, Paris.

Mancicorpus anchoriforme Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961

Plate XXXIV, Figures 5, 6.

1961 Mancicorpus anchoriforme Mtchedlishvili in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 219, pl. 70, figs. 3a-c, 4a-b.

1961 Tricerapollis unicus Chlonova; Trudy Inst. Geol. Geophys., Acad. Nauk SSSR, Novosibirisk, vol. 7, p. 86, pl. 15, fig. 110.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and one projection developed on one of the poles, pollen-body reduced to concavity on the other pole; equatorial projections well developed, meridional, long, arise from polar areas, extend into round apices, projected in the direction of reduced pole; tricolpate, colpi long, meridional across the apices of equatorial projections, extending towards polar regions; sexine tectate, more compact and thick in polar areas, thickens meridionally on equatorial projections, sexine clavate in apical and equatorial regions of equatorial projections, clavae large, protruding slightly above surface like blunt small spinules with their apices directed towards polar regions.

SIZE RANGE: Polar axis 22.4 to 37.6 microns, average 31.4 microns; equatorial axis (including equatorial projections) 38.3 to 49.1 microns, average 44.4 microns (Samoilovitch and Mtchedlishvili

1961); distance from the center of polar axis to the tips of equatorial projection 30.4 microns, breadth of apices of equatorial projections 13.6 microns.

ILLUSTRATED SPECIMENS: EC 5/1 : 46/127.9, Pl. XXXIV, Figs. 5, 6.

LOCALITY: East Coulee Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: M. anchoriforme has larger equatorial and polar projections than M. albertensis. The polar projection in M. anchoriforme is broad and round while that of M. albertensis is narrow and bluntly conical. M. anchoriforme is reported from the lower Maestrichtian of Siberia also (Samoilovitch and Mtchedlishvili 1961).

Mancicorpus solidus Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961

Plate XXXIV, Figures 7, 8.

1961 Mancicorpus solidum Mtchedlishvili in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Gecl.-Razv. Inst., Leningrad, vol. 177, p. 223, pl. 22, figs. 1a-c.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and with one projection each on the proximal and distal polar region, heteropolar, one polar projection very well developed, broad, round, the reduced polar projection is like a small hump; equatorial projections well developed, meridional, arising from the neck region of developed polar projection and tip of reduced polar projection, apices broadly round, a little broader than central region of equatorial projections; tricolpate, colpi long, meridional across

the apices of equatorial projections, extending up to the contact area towards polar projections on both sides of equatorial projections; sexine tectate, baculate, thickens meridionally extending up to the apical regions of equatorial projections; ornamentation retipilate; echinate, breadth of spinules at base about 1 micron, length 1.6 microns, acuminate, scattered all over body, concentrated generally at polar projections and apical regions of equatorial projections, tips of spinules directed toward polar projections.

SIZE RANGE: Polar axis 35 to 40 microns; equatorial axis (including the length of two equatorial projections) 39 to 71 microns; distance from the center of polar axis to the tips of equatorial projections 29 to 34.7 microns; apical breadth of equatorial projections 13 to 20 microns.

ILLUSTRATED SPECIMENS: DH 39/1 : 33.8/121.8, Pl. XXXIV, Figs. 7, 8.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: M. solidus has broad well developed polar and equatorial projections with retipilate ornamentation to distinguish it from other similar species.

Mtchedlishvilia n. gen.

TYPE SPECIES: Mtchedlishvilia canadiana n. sp.

DIAGNOSIS: Pollen grains with three well developed equatorial projections and without any polar projections, polar axis considerably compressed compared to equatorial axis; tricolpate, colpi meridional,

long or short, across the equatorial projections; sexine thin, variable ornamentation.

REMARKS: Mtchedlishvilia can be distinguished from the genus Translucentipollis Chlonova in being tricolpate and lacking polar projections.

The generic name is given in honor of Dr. (Mrs.) N. D. Mtchedlishvili, VNIGRI (Oil Institute), Leningrad, U.S.S.R.

Mtchedlishvilia canadiana n. sp.

Plate XXXV, Figures 1-8.

DESCRIPTION: Pollen grains with three equatorially situated apical projections and without any developed polar projections, polar axis considerably compressed, equatorial projections well developed, long, equatorially connected with each other by thin sexine, a meridional ridge of thicker sexine from pole to pole across the equatorial projections present; tricolpate, colpi small, meridional across apices of equatorial projections, extending up to the thickened sexinous region of equatorial projections; sexine reticulate, reticula large with high muri on polar regions, muri become low toward equatorial region, colpi margins echinate, spinule bases broad, tips acuminate and curved toward poles.

SIZE RANGE: Polar axis not certain; equatorial diameter 40.0 to 70.0 microns; apical breadth of equatorial projections 8.0 to 12.0 microns.

HOLOTYPE DIMENSIONS: Polar axis not certain; equatorial diameter 64.0 microns, apical breadth of equatorial projections 10.4 microns.

HOLOTYPE PREPARATION: BT 7/1 : 27.6/112.8, Pl. XXXV, Figs. 1, 2.

ILLUSTRATED SPECIMENS: DH 4/1 : 62.5/111.0, Pl. XXXV, Figs. 3, 4; DH 4/1 : 42.1/111.5, Pl. XXXV, Figs. 5, 6; EC 6/3 : 57/123.8, Pl. XXXV, Figs. 7, 8.

LOCALITY: Betty Tolman Locality, Drumheller Locality, East Coulee Locality, lower and middle divisions, Edmonton Formation; Maestrichtian.

REMARKS: Mtchedlishvilia canadiana is tricolpate and reticulate with echinate apical regions to distinguish it from M. glaber (Chlonova) n. comb. which is a smooth form. Although Chlonova suggested M. glaber as a triporate pollen, with the study of many such specimens it seems that M. glaber may be tricolpate.

Genus Wodehousea Stanley 1961

1961 Wodehouseia Stanley; Pollen et Spores, vol. 3, no. 1, p. 156.

1961 Kryshtofoviacites Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 230.

1961 Ocellipollis Chlonova; Trudy Inst. Geol. Geophys., Acad. Nauk SSSR, Novosibirisk, vol. 7, p. 80.

1961 Deplexipollis Chlonova; Trudy Inst. Geol. Geophys., Acad. Nauk SSSR, Novosibirisk, vol. 7, p. 81.

TYPE SPECIES: Wodehousea spinata Stanley 1961.

REMARKS: Wodehousea Stanley has seniority over Ocellipollis Chlonova, Deplexipollis Chlonova and Kryshtofoviacites Samoilovitch. Genus Ocellipollis Chlonova has been erected on pollen whose equatorial flange has been peeled. Pollen with a half peeled flange have been

noticed which indicate that Ocellipollis is peeled Wodehousea (Pl. 36, Fig. 3).

There is no definite opinion about the orientation of pollen, although the diagrams given by Chlonova (1961) are suggestive that the length of pores may be aligned meridionally. In that case, Wodehousea has a compressed polar axis and a long equatorial axis. However, in the present study, the longer axis is referred as the longitudinal axis or the length of the pollen and the shorter axis as the breadth of the pollen.

Chlonova (1966) suggested the affinity of Wodehousea with the extant genera Impatiens of family Balsaminaceae and Jollydora of family Connaraceae. Peeled specimens of Wodehousea (referred Ocellipollis by Chlonova 1961, 1966) are echinate while Wodehousea has a flange and spines on body. Pollen of Impatiens and Jollydora are reticulate, angulaperturate and devoid of flange.

Wodehousea spinata Stanley 1961

Plate XXXVI, Figures 1-3.

1961 Wodehouseia spinata Stanley; Pollen et Spores, vol. 3, no. 1, p. 157, pl. 1, figs. 1-12.

1961 Kryshtofoviana vera Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 233, pl. 75, figs. 1a-d, 2, 3a-c.

1961 Deplexipollis oculatus Chlonova; Trudy Inst. Geol. Geophys., Acad. Nauk SSSR, Novosibirisk, vol. 7, p. 81, pl. 13, figs. 96, 96a.

ILLUSTRATED SPECIMENS: Sc 2-B/4 : 22.8/112.0, Pl. XXXVI, Fig. 1; Sc 2-B/4 : 36/120, Pl. XXXVI, Fig. 2; Sc 2-C/1 : 54.2/116.9, Pl. XXXVI, Fig. 3.

LOCALITY: Scollard Locality 2, upper division, Edmonton Formation; Maestrichtian.

REMARKS: W. spinata has been recorded from Maestrichtian to Paleocene strata of Siberia (Samoilovitch and Mtchedlishvili 1961; Chlonova 1961; Bratzeva 1965, 1967) and from Maestrichtian strata of U.S.A. (Stanley 1961, 1965; Norton and Hall 1965) and Canada (Srivastava 1966, 1967).

Wodehousea gracile (Samoilovitch in Samoilovitch and Mtchedlishvili) Samoilovitch 1967

Plate XXXVI, Figures 4, 5.

1961 Kryshtofoviana gracile Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 237, pl. 76, figs. 1a-c.

1967 Wodehouseia gracile (Samoilovitch in Samoilovitch and Mtchedlishvili) Samoilovitch; Rev. Palaeobotan. Palynol., vol. 2, p. 132, pl. 2, fig. 6.

ILLUSTRATED SPECIMENS: DH 40/2 : 44.4/115.0, Pl. XXXVI, Fig. 4; DH 35/2 : 67.7/123.9, Pl. XXXVI, Fig. 5.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: W. gracile can be distinguished from W. spinata in having more spines on body and a wider flange.

W. gracile has been recovered from Maestrichtian to Danian strata of Siberia (Samoilovitch and Mtchedlishvili 1961).

Wodehousea jacutense (Samoilovitch in Samoilovitch and Mtchedlishvili) Samoilovitch 1967.

Plate XXXVI, Figures 6, 7.

1961 Kryshtofoviana jacutense Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 237, pl. 76, figs. 2a-d, 3a-c.

1967 Wodehousea jacutense (Samoilovitch in Samoilovitch and Mtchedlishvili) Samoilovitch; Rev. Palaeobotan. Palynol., vol. 2, p. 132, pl. 2, fig. 6.

ILLUSTRATED SPECIMENS: DH 35/1 : 51.5/124.8, Pl. XXXVI, Fig. 6; DH 35/1 : 24/124.6, Pl. XXXVI, Fig. 7.

LOCALITY: Drumheller Locality, lower division, Edmonton Formation; Maestrichtian.

REMARKS: Samoilovitch and Mtchedlishvili (1961) reported the occurrence of W. jacutense from the Danian strata of Siberia.

The Albertan specimens of W. jacutense have a narrower flange than Siberian specimens.

Wodehousea fimbriata Stanley 1961

Plate XXXVI, Figures 8, 9.

1961 Wodehousea fimbriata Stanley; Pollen et Spores, vol. 3, no. 1, p. 160, pl. 2, figs. 1-8.

1961 Regina excelsa Samoilovitch in Samoilovitch and Mtchedlishvili; Trudy Vses. Neft. Nauch.-Issled. Geol.-Razv. Inst., Leningrad, vol. 177, p. 240, pl. 77, figs. 1a-f.

ILLUSTRATED SPECIMENS: Sc 2-7/1 : 55.7/119.9, Pl. XXXVI, Figs. 8, 9.

LOCALITY: Scollard Locality 2, upper division, Edmonton Formation; Maestrichtian.

REMARKS: W. fimbriata can be distinguished from other species of Wodehousea in having a very wide and thick flange and fimbriate pattern on the flange.

W. fimbriata has been recorded from Maestrichtian to Paleocene strata of Siberia (Samoilovitch and Mtchedlishvili 1961), Lower Paleocene of U.S.A. (Stanley 1961) and lowermost Tertiary (Tullock Formation) in Montana, U.S.A. (Norton and Hall 1967.)

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APPENDIX A

REVIEW OF RECENT LITERATURE ON

UPPER CRETACEOUS PALYNOLOGY

REVIEW OF RECENT LITERATURE ON UPPER CRETACEOUS PALYNOLOGY

Pertinent literature on Upper Cretaceous palynology, available until 1964, has been reviewed by Srivastava (1965). Since then a considerable amount of work on this epoch has been published which is reviewed here. A comprehensive review of Upper Cretaceous palynology has already been published (Srivastava 1967b).

ALASKA

The presence of Aquilapollenites, Wodehousea, Orbiculapollis, and Pachysandra has been reported in the Upper Cretaceous (Maestrichtian) sediments from the Ivishak River Country, Alaska. These samples are referred stratigraphically to the Kogosukruk tongue of the Prince Creek Formation (Tabbert 1966).

CANADA

Capulisporites longiprocessum Hills & Jensen, a trilete megaspore with a trifolium and long processes, has been reported from the Belly River Formation (Campanian) of Alberta, Canada. This species seems to be restricted to pre-Edmonton Formation age (Hills and Jensen 1966). Elsik (1966) has transferred this species under his newly created genus Caudaspora Elsik, thus forming a new combination, Caudaspora longiprocessum (Hills & Jensen) Elsik 1966.

A palynological study of the Late Cretaceous (Maestrichtian) mammal beds, belonging to the upper and middle Edmonton Formation from the Scollard area in Alberta, revealed a rich pollen and spore assemblage (Srivastava 1965, 1966, 1967a). These microspores could be assigned

to ninety species belonging to fifty-nine genera. Five new genera - Ghoshispora, Salixipollenites, Carpinites, Cranwellia, and Scollardia - have been diagnosed. The microfloral spectrum could be divided into five assemblages on the basis of appearance and disappearance of various species. Aquilapollenites, Wodehousea, Polycolpites, and Ghoshispora played an important role in zoning the microfloral spectrum. From the lowest microfloral assemblage to the uppermost one, in a span of about three million years, the climate changed from humid tropical to subtropical with warm temperate aspects. Thirty-three families representing pteridophytes, gymnosperms, and angiosperms have been recognized. In the modern distribution, many of the equivalents are restricted to areas ranging from tropical to subtropical.

Srivastava (1968a) discussed the generic diagnoses of the genera Aquilapollenites Rouse emend. Funkhouser and Mancicorpus Mtchedlishvili. He restricted the generic circumscription of Aquilapollenites and described fifteen species with reticulate ornamentation from the Edmonton Formation (Maestrichtian). The described species are: Aquilapollenites amicus Srivastava, A. amygdaloides Srivastava, A. antigonei Srivastava, A. cateniretiaulatus Srivastava, A. ceriocorpus Srivastava, A. debilis Srivastava, A. leucocephalus Srivastava, A. medeis Srivastava, A. mirabilis Srivastava, A. oblatus Srivastava, A. stelckii Srivastava, A. validus Srivastava, A. venustus Srivastava, A. dolium (Samoilovitch) Srivastava, A. funkhouseri Srivastava, and A. reductus Norton. Also he discussed the distinguishing characteristics of eleven other reticulate species of Aquilapollenites already described in literature: Aquilapollenites alveolatus Jardine & Magloire, A. borealis Takahashi, A. chlonovae Srivastava, A. minimus Jardine & Magloire,

A. mtchedlishviliae Srivastava, A. procerus Samoilovitch, A. recticulatus Stanley, A. rombicus Samoilovitch, A. senegalensis Jardine & Magloire, A. trialatus Rouse, and A. triauritus Takahashi.

The genus Mancicorpus has only one polar and three equatorial projections developed. Many pollen having only one polar projection have been described under the genus Aquilapollenites, of which Srivastava (1968a) transferred the following to the genus Mancicorpus: Mancicorpus pulcher (Funkhouser) Srivastava, M. pulvinus (Stanley) Srivastava, M. pyriformis (Norton) Srivastava, M. striatus (Funkhouser) Srivastava.

Srivastava (1968) studied ephedralean pollen from the Edmonton Formation (Maestrichtian) and discussed their paleoecological significance. The diversity in distribution and the wide range of adaptability of Ephedra in the modern flora precludes precise interpretation of paleoecological conditions. He speculated that the modern members of Ephedra are the remnants of a larger group in the past distributed in diverse ecological conditions, ranging from xeric to humid climates. The form-genera Equisetosporites Daughterty emend. Singh, Gnetaceaepollenites Thiergart emend. Srivastava, Steevesipollenites Stover, and Singhia Srivastava have ephedralean affinity. Eight species recovered from the Edmonton Formation are: Equisetosporites amabilis Srivastava, E. lajwantis Srivastava, E. menakae Srivastava, E. mollis Srivastava, Gnetaceaepollenites nobilis Srivastava, G. oreadis Srivastava, G. ventrosus Srivastava, and Singhia urwashii Srivastava.

WESTERN UNITED STATES OF AMERICA

In a palynological investigation of the Upper Cretaceous and lower Tertiary sediments, exposed in four stratigraphic sections in

Harding County, South Dakota, 80 species of plant microfossils are assigned to 53 genera; 19 species of dinoflagellates and hystrichospherids belonging to 11 genera are described. The genera Aenigmapollis, Pseudotricolpites, and Trialapollis are diagnosed (Stanley 1965). The microspore assemblage indicated late Upper Cretaceous age in the Crow Butte section. A marked difference between this microflora and the Upper Cretaceous microflora of Europe and Australia has been noted. The most closely resembling microflora is that described by Samoilovitch and Mtchedlishvili (1961) from the Upper Cretaceous of western Siberia. Based on plant microfossils, Stanley (1965) divided the Crow Butte Section into three "Zones". The characteristic species of "Zone I" are Hamulatisporis hamulatis Krutzsch, Gleichenia triangula Stanley, Schizaea plectilis Stanley, and Cupanieidites speciosus Stanley; "Zone II", Leptolepidites tenuis Stanley, Anemia tricornitata (Weyland & Griefeld) Stanley, Schizosporis microfoveatus Stanley, Pterocarya levis Stanley, Aquilapollenites amplus Stanley, A. murus Stanley, A. pulvinus Stanley, A. reticulatus Stanley, and Triatriopollenites pseudomagnificus Stanley; and "Zone III", Trialapollis scabratus Stanley.

Maestrichtian in the type area of the Marca Shale and the Dos Palos Shale Member of the Moreno Formation, at Escarpado Canyon, California, is characterized by the phytoplankton species Gymnodinium nelsonense Cookson, Deflandrea cretacea Cookson, Hystrichosphaera suppara Drugg, and by the microspore species Triporopollenites marcaensis Drugg of probably symplocaceous affinity, and Quadripollis krempii Drugg, with abundance of Proteacidites thalmanii Anderson. P. thalmanii, thought to be restricted to the Cretaceous by Anderson (1960), has scattered occurrence in the Danian also. Areoligera volata Drugg, Hystrichosphaeridium

magdalium Drugg, Cannosphaeropsis elegantula Drugg, Spinidinium densispinatum Stanley, and Palmnickia californica Drugg have been frequently encountered and seem to be restricted to the Danian. The characteristic microplankton species of the lower part of the Danian section at Escarpado Canyon are Trithyrodinium evittii Drugg and Peridinium basilium Drugg. Gonyaulax pyra Drugg and Palmnickia californica are abundant in the lower part of the Danian and rare in the upper levels. No pollen or spore species has been recorded as characteristic of the lower Danian. The upper part of the Danian is characterized by the abundant and restricted presence of the microplankton species Cordosphaeridium inodes (Klumpp) Eisenack, and Glyphanodinium facetum Drugg. Nudopollis terminalis hastaformis (Pflug & Thomson) Pflug is abundant and restricted to the upper Dos Palos. A warm-temperate to subtropical climate has been envisaged on the basis of the microspore assemblage in the Escarpado Canyon region during the Maestrichtian-Danian times (Drugg 1966, 1967).

The characteristic pollen species of the Upper Cretaceous palynomorph assemblage from the upper Lance-Fort Union interval of the type Lance area, Wyoming, are Proteacidites sp., Aquilapollenites sp., Wodehousea spinata Stanley, Krutzipites trispitssatus, and Gunnera sp. Three palynological zones could be delineated. The microspore assemblage of the upper zone is characterized by a predominance of alder pollen and triporate grains of betulaceous and juglandaceous affinities. The intermediate transitional zone is characterized by abundant, small sized tricolpate and tricolporate pollen grains, by Wodehousea fimbriata Stanley, and by occasional Anemia spores (Leffingwell 1966).

Hall and Norton (1967) analysed the percentage composition

of pollen flora of the latest Cretaceous and early Tertiary of mid-continent U.S.A. They found that the "absolute number" of species declines from Cretaceous to Tertiary, but percentage of ferns does not change. Dicotyledon species have been found more in the Cretaceous than Tertiary and gymnosperm species are less in the Cretaceous than Tertiary time. They suggested that these differences may be related to the change of climate from Cretaceous to Tertiary time.

Norton and Hall (1967) listed 14 microspores which they found characteristic of either the Hell Creek Formation (Uppermost Cretaceous) or Tullock Formation (lowermost Tertiary) of eastern Montana. They diagnosed the genus Styx Norton and Hall and described four species, Styx minor Norton in Norton and Hall, S. major Norton in Norton and Hall, Tricolpites parvistriatus Norton in Norton and Hall, T. cellatus Norton in Norton and Hall. Genus Styx seems to be a junior synonym of Balmeisporites.

EASTERN UNITED STATES OF AMERICA

Nine species belonging to six genera of dispersed fungal spores have been described from five coal beds of the Vermejo Formation (Upper Cretaceous) of central Colorado. Three genera (Lacrimasporonites, Involutisporonites, and Fractisporonites) have been diagnosed. Fungal spores occurred sparsely in all the coal beds and accounted for far less than 0.5 percent of the total palynomorph assemblage; they are not useful in zoning (Clarke 1965).

An assemblage of Late Cretaceous pollen and spores was recovered from the samples of black sandy clay from the Appalachian Mountains region near Chambersburg, Pennsylvania. With the evidence

of the known stratigraphic ranges of some forms, and the number and percentage of triporate pollen, an age range extending from early Turonian to middle Campanian is indicated (Tschudy 1965).

Tschudy (1966a) recovered many megaspores and microspores from the Tuscaloosa Formation (Late Cretaceous) of Alabama. These morphologically similar megaspores and microspores were found in masses joined by intertwined long distal hairlike appendages. On the assumption that these two spore types are the megaspores and microspores of the same species, Tschudy described them under the name Ariadnaesporites cristatus Tschudy. The leaflike extensions of the lips of laesurae have been termed "acrolamellae". A similar leaflike structure has been described as "trifolium" in Capulitriletes by Potonié (1956). Also, Tschudy (1966a) has emended the genus Ariadnaesporites Potonié 1956.

Twenty-seven species belonging to 20 genera are described from the marine Upper Cretaceous formations of Delaware and New Jersey which form a part of the Cretaceous-Cenozoic sedimentary sequence underlying the Atlantic Coastal Plain of the eastern United States (Gray and Groot 1966).

In a palynological investigation of the Red Branch Member of the Woodbine Formation (Cenomanian), Bryan County, Oklahoma, the spores and pollen recovered could be assigned to 45 genera and 71 species. The absence of marine palynomorphs suggested a non-marine depositional environment. The microspore assemblage suggested a warm-temperate to tropical climate during which the Red Branch sediments were deposited in numerous local, swampy basins along the Cenomanian coastal plain. Upland floristic elements were probably derived from the cooler elevated areas to the north. The closest palynologic correlation appeared to be with

the Cenomanian of Minnesota (Hedlund 1966).

The Raritan Formation of New Jersey, considered to be the earliest Late Cretaceous, has yielded plant microfossils suggesting subtropical to temperate climate. The presence of marine microfossils indicated a shallow-water marine environment of deposition. Two new genera and 36 new species have been described from the Raritan Formation (Kimyai 1966).

EUROPE

Microspore contents of Aachenian Cretaceous (middle Senonian) show the dominance of pollen over spores. Many of these spores belong to the Schizaeaceae family. The triangular shaped pollen, which are in abundance, may belong to the family Amentaceae. A few forms of these may even extend to early Tertiary times (Weyland and Krieger 1953).

Cuticular and microspore studies of the lower Senonian clays of the Quedlinburg region have shown the presence of Lycopodiaceae, Schizaeaceae, many Gymnosperms, and dicotyledonous Angiosperms (Weyland and Greifeld 1953).

A few spores and pollen from the Cenomanian beds of Bohemia have been described by Thiergart (1953).

Many transitional forms of angiospermous heteropolar pollen with a clear trilete mark have been recorded in abundance in the Upper Cretaceous and Paleocene beds. They disappear slowly in the early Tertiary and are rarely present in the middle Tertiary. In the Senonian of Aachen, such pollen have shown remarkable development of the furrows on the protrusions. Subsequently furrows have thinned considerably and ultimately disappeared, thus merging with the inaperturate pollen (Pflug

1953).

Krutzsch (1957, 1959) described many form-genera and form-species of spores and pollen from Middle European Upper Cretaceous and Tertiary and discussed their stratigraphic importance. He (1961) described Reticulosporis oebisfeldensis Krutzsch and R. reductus Krutzsch from the upper Campanian/lower Maestrichtian strata of the Oebisfelde locality of north Germany. These spores have botanical affinity with the genus Schizaea, particularly the "Schizaea pusilla group".

Weidmann (1963) investigated the palynology of "complex schisteux intermediaire" ranging from Albian to Turonian Age and showed the comparative distribution of different planktons, spores, and pollen in the Albian, Cenomanian, and Turonian.

Pollen and spore assemblages from "Wealden" of Leon province (northern Spain) have been studied, and the strata have been placed within the lower part of the Upper Cretaceous, possibly Cenomanian-Turonian. Two genera, i.e., Classoidites and Psittacopollis, have been diagnosed and 12 species described (Ameron 1965).

CORRELATIVE DISCUSSION ON THE UPPER CRETACEOUS FLORA OF UNITED STATES AND EUROPE

On comparing the Senonian microflora of western Europe, northeastern North America, and western North America, Gray and Groot (1966) tentatively concluded that the pollen of northeastern United States are morphologically more "modern" than those of western Europe, and more "primitive" than those of western United States. In the evolutionary sense the pollen of northeastern United States are intermediate between the two other areas mentioned. Tschudy (1966b)

noted a greater similarity of the Cretaceous and Paleocene pollen floras of the Mississippi Embayment with the European pollen floras than with those from the northern Rocky Mountains. The Rocky Mountain pollen floras show closer similarities to the Alaskan and Siberian floras. The floral dissimilarity may be accounted for by the separation of the Rocky Mountain province from the Mississippi Embayment during late Cretaceous time by the great north-south trending Cretaceous epeiric sea.

SOUTH AMERICA

The genus Auriculiidites Elsik has been diagnosed and reported from the Vivian Formation (Campanian) of eastern Peru, and one species, A. reticulatus Elsik, has been assigned to it (Elsik 1964). From the Campanian of Peru, Elsik (1966) described a new elator-bearing spore, Caudaspora, and also the genera Thecaspora and Cyclusphaera.

Van der Hammen and Wymstra (1964) studied the palynology of the Tertiary and Upper Cretaceous of British Guiana.

Boer, van der Hammen, and Wymstra (1965) discussed the results of a palynological investigation of borehole samples from the Amazonas Delta area of northwest Brazil. The samples of one of the holes showed Lower to MiddleCretaceous age, and those from the two other boreholes had Upper Cretaceous to Lower Tertiary flora. Tectonic and stratigraphic consequences of the palynological study have been discussed, and a comparison between the Marajó and Guiana Basins has been made.

The Upper Cretaceous flora in northeastern Brazil is characterized by Cicatricosisporites, Araucariacites, Polyplicates, Triptyches, Ptychotriporines, Triporines, cf. Ulmipollenites, and

Polyporines (Müller 1966).

AFRICA

As far back as 1932, Kirchheimer described conifer and angiosperm pollen from a dysodil (sapropelic coal) belonging to the Upper Cretaceous of Namaqualand (South Africa). The microfossil flora did not compare with the present day flora, suggesting a change in the ecological character of the area.

Two groups of sporomorphs of uncertain taxonomic position have been recovered from the Upper Cretaceous of Gabon (West Africa). The group of sporomorphs having three or four subpolar or subequatorial pores and a rudimentary tri-radiate mark was called Porotrichotomosulques or Porotrichotomosulcates. The rudimentary tri-radiate mark has been thought to be a rudimentary sulcus. The possibility of the trichotomosulcus developing into three pores has been discussed and compared with palm pollen. The other group, called Pre-pollens, have three meridional colpi and a polar tri-radiate mark. An attempt has been made to trace the evolution of the sulcus in these forms; stratigraphically, they appear sporadically without any effective vertical distribution. Generally, certain new forms have appeared in the lower Senonian (Belsky and Boltenhagen 1963). Pollen grains of similar morphological characters have been described by Demchenko (1966) from the recent genera of the family Neuradaceae. Boltenhagen (1965) summarized the stratigraphic palynology of the sedimentary basins of Equatorial Africa. The succession of microflora in the strata corresponded to the major stages of plant evolution in Equatorial Africa.

Further work on the Upper Cretaceous of Gabon classified

the microspores morphologically. Five new genera have been diagnosed: Constantinisporis, Victorisporis, Andreisporis, Myrtacidites, and Pediculisporis (Belsky, Boltenhagen, and Potonié 1965).

Boltenhagen (1967) described ten typical forms from the Upper Cretaceous of Gabon. Genus Gabonisporis Boltenhagen, Buttinia Boltenhagen, and Hexaporotricolpites Boltenhagen have been diagnosed and six species described. The six species are: Gabonisporis vigourouxii Boltenhagen, Buttinia andreevii Boltenhagen, Rhoipites hirtzii Boltenhagen, Cupanieiditis acuminatus Boltenhagen, Hexaporotricolpites emelianovii, and Auriculiidites hourcqui Boltenhagen. Gabonisporis vigourouxii occurs abundantly in lower and middle Edmonton Formation of Alberta, Canada.

Jardine and Magloire (1965) described characteristic spores and pollen assemblages from the Cretaceous sediments of Senegal and the Ivory Coast (West Africa). Evolutionary changes in microspores and qualitative and statistical analyses permitted a division of Aptian to uppermost Maestrichtian sediments into definite sequences. The distribution of Galeacornea Stover and Classopollis extended into the Cenomanian, and the genus Aquilapollenites remained restricted to the upper part of the Maestrichtian in the Senegal and Ivory Coast Basins.

Paleoecological affinities between Africa, the Indo-Malayan region, Australia, and New Zealand during the Cretaceous time have been indicated on the basis of the distribution of fossil pollen of Nothofagus, Podocarpus, Araucaria, Dipterocarpus, and several others representing Proteaceae, Bombax, Alangium, Acacia, Albizzia, and Palmae (Puri 1965). Van Hoeken-Klinkenberg (1966) described pollen and spores from borehole samples of the Maestrichtian, Paleocene, and Eocene of Nigeria. The species restricted to Maestrichtian are Constructipollenites ineffectus

van Hoeken-Klinkenberg and Cingulatisporites ornatus van Hoeken-Klinkenberg. Gemmatricolpites scabratus van Hoeken-Klinkenberg, Syncolporites minutus van Hoeken-Klinkenberg, Scabratriporites annellus van Hoeken-Klinkenberg, and Ctenolophonidites costatus (van Hoeken-Klinkenberg) van Hoeken-Klinkenberg are characteristic species of the Maestrichtian but extend into the lower Paleocene also. Proxapertites operculatus van der Hammen is restricted to Paleocene strata.

Spores, pollen, and hystrichospheres recovered from the Cretaceous deposits of the Tano Basin of Ghana were indicative of Cenomanian-Senonian age (Baltes 1966).

The presence of the genus Azolla, together with angiosperms, gymnospermous, and pteridophytic microspores, and hystrichospheres, has been reported from the Upper Cretaceous of Senegal (Kieser 1966).

A palynological investigation of well samples from south of Tunisia provided constant characteristics in palynofacies which were correlative with the subsurface samples of the Lower Sahara (Algeria). The sediments belong to the Middle Cretaceous (Reyre 1966).

Van Zinderen Bakker (1966, 1967) reviewed the palynological and paleoecological work done in Africa, the surrounding islands, and Antarctica during 1950-1965. Srivastava (1966a) reviewed and discussed the African palynology in its international aspects.

RUMANIA

Cretaceous microfloral complexes and microplanktonic assemblages from the Moesic Platform of Rumania have been discussed (Baltes 1963, 1965). Baltes (1966a) has summarized the Cretaceous microfloristic complexes of the Moesic Platform of Rumania and noted

the distinctive characters of each assemblage.

USSR

Bolkhovitina (1953, 1959) described characteristic spores and pollen from the Cretaceous of the central part of the USSR. Voyevodova and Khaikina (1960) described spore-pollen complexes of the northeastern USSR belonging to the Upper Cretaceous. Zalinskaya (1960) showed the significance of angiospermous pollen for the stratigraphy of the Upper Cretaceous and Paleogene. Chlonova (1957, 1960, 1961) described many spores and pollen grains from the Upper Cretaceous of Siberia in the USSR. Samoilovitch and Mtchedlishvili (1961) described and illustrated many genera and species from Jurassic to Paleocene formations of Russia. Chlonova (1962) classified many spores and pollen of the Upper Cretaceous from the eastern part of the western Siberian lowland into "radiata", "unica", and "oculata" types. Bolkhovitina (1962) traced the history of the family Schizaeaceae in the geologic past on the basis of spore studies and noted a reduction of generic distribution of Schizaeaceae during the Upper Cretaceous and Tertiary of Siberia and Europe as compared with the distribution in the Lower Cretaceous. Bratzeva (1962) reported data on the fossil flora from beds corresponding to the Cretaceous-Paleogene boundary in the Zeya-Bureya depression in Russia.

Pacltova (1963) summarized the observations on the palynologic investigations of the Cretaceous and Tertiary in the USSR. Schopf (1964) reviewed the present position of palynology in Russia, taking into account the literature and its application to exploration there.

The spore and pollen data have pointed towards a relationship between Upper Cretaceous and Paleogene floras of Australia, New

Zealand, and Eurasia. The highly organized structure of angiospermous pollen in the Upper Cretaceous and the presence of many forms belonging to recent genera indicate that the age of the Angiosperm flora is much older than the Cretaceous (Zalinskaya 1964).

Bratzeva (1965) described 31 species belonging to 13 genera from the Maestrichtian deposits of Far East. Bratzeva (1967) discussed the microflora recovered from the Tsagaiansk deposits of the Zeya-Bureya depression. The Tsagaiansk microflora is of Maestrichtian Age and is comparable to the Maestrichtian flora of North America.

Chlonova (1966b) described from the USSR three species of "Oculata" type pollen: Ocellipollis munitus Chlonova, O. obliquus Chlonova, and Wodehousea tetraptra Chlonova.

Four paleobotanical regions - Tazov, Chulymo-Yenisei, Priyenissei, and Priob areas - could be distinguished in the west Siberian lowland on the basis of differences in specific composition and in the percentage of themain elements (Grigorieva 1966).

The palynological data, from the Upper Cretaceous deposits in the basin of the lower reaches of the Anadyr River and on the coast of the Bering sea, showed some common elements in the Upper Cretaceous flora of northeast Asia and the present flora of Australia and New Zealand. The similarity of spore and pollen assemblages in eastern Siberia, the Far East, Sakhalin, Kamchatka, and the Anadyr section indicates that this region was apparently within the east Asiatic botanic-geographic province during the Upper Cretaceous. A definite zonation in vegetation distribution began in the Paleogene due to the change in the physico-geographical conditions (Khaikina and Belaia 1966).

Schizaeaceous spores almost disappear in the Maestrichtian and Danian. Anemia is dominant during Cenomanian and Turonian, whereas Schizaea is present mostly in the assemblages from Senonian to Maestrichtian-Danian. Mohria spores are present in small quantities from Valanginian to Cenomanian. The largest number of species of Schizaeaceae spores, similar to Siberian ones, is in Canada (Markova 1966).

Samoilovitch (1967) has also noted a botanico-geographical subdivision of northern Asia in late Senonian-Danian time on the basis of the palynologic data.

Skuratenko (1966) described three spore-pollen assemblages from the Turonian strata of west Siberia. The first assemblage from the central, southern, and southeastern part of the lowland is characterized by a large number of angiosperms: e.g., Elytranthe striatus Couper, Azonia fabacea Samoilovitch, Gothanipollis sp. Gymnospermous pollen with a large amount of Taxodiaceae pollen are prevalent in this assemblage. In the second assemblage from the continental deposits, the amount of angiospermous pollen decreases and various spores (especially those of the family Schizaeaceae) are present. The third spore-pollen assemblage is from the littoral, continental, and marine deposits of the northeast region of the lowland. This assemblage is poor in angiospermous pollen. The presence of Leiosphaera scrobiculata Cookson & Dettmann and Balmeisporites Cookson & Dettmann is an interesting feature of this assemblage.

Takhtajan (1966) described in detail the major Late Cretaceous phytochoria (plant assemblages) in the USSR and adjacent countries and noted the climatic conditions prevailing during those times.

Palynologically, the last basic rearrangement of the flora

and its complete renovation took place at the Upper Cretaceous-Paleogene boundary, i.e., Maestrichtian-Danian-Paleocene time. Maestrichtian flora was differentiated in the Northern Hemisphere and plant taxa of regional and general biostratigraphic significance were developing within floristic areas and provinces. Taxa of unknown affinity, e.g., Aquilapollenites, Normapolles Pflug, Duplosporis Pflug, Wodehousea, Triporina unica Chlonova, Sporopollis Pflug, are recovered. The majority of these taxa are characterized by an adaptive radiation during the Maestrichtian (Zalinskaya 1966).

JAPAN

Palynological analysis of the carbonaceous matter belonging to the Upper Cretaceous of the Hakobuchi group in the Enbetsu district, northern Hokkaido, revealed the presence of Aquilapollenites quadrilobus Rouse, A. hakobuchiensis Sato, and Aquilapollenites sp. (Sato 1961).

The spore-pollen assemblages of the Upper Cretaceous (Campanian and Maestrichtian) of the Hakobuchi group in Hokkaido are mainly composed of trilete spores, monolete spores, non-aperturate conifer pollen, and polyporid pollen. The genus Aquilapollenites has been significant for biostratigraphic correlation. Aquilapollenites triauritus, A. borealis, A. matsumotoi Takahashi, Aquilapollenites sp. a, b, c, and d are reported from the Campanian beds and A. quadrinus Takahashi from the Maestrichtian. Campanian, Maestrichtian, and Paleocene beds could be differentiated with the help of the spore and pollen assemblages. Pteridophytes declined remarkably from the Upper Cretaceous to the Paleogene deposits (Takahashi 1964, 1965, 1966; Shimada 1966).

AUSTRALIA AND NEW ZEALAND

Cookson (1955) reported the occurrence of Paleozoic microspores in Australian Upper Cretaceous and Lower Tertiary sediments. Cookson and Dettmann (1958) described some trilete spores from Upper Mesozoic deposits in the Eastern Australian region and they (1959) established the form-genus Schizosporis from the Cretaceous deposits of Australia. Couper (1953) described several spores and pollen grains from the upper Mesozoic and Cenozoic of New Zealand. He (1953, 1953a) recorded widespread distribution of some members of Proteaceae, Fagaceae, and Podocarpaceae in some Southern Hemisphere Cretaceous and Tertiary beds, although these families have limited distribution in those parts in the present-day flora. Couper (1954) described seven species of plant microfossils from Upper Cretaceous and Tertiary freshwater beds. He (1960) systematically described 139 species and correlated Upper Cretaceous and Tertiary freshwater deposits with the marine stages of New Zealand. Cookson and Eisenack (1962) reported some Cretaceous and Tertiary microfossils of uncertain affinity from Western Australia. Norris (1962) described type specimens of Mesozoic and Cenozoic spores and pollen grains from New Zealand.

MEGASPORES AND OTHER PLANT MICROFOSSILS

Very little work has been done on Upper Cretaceous megaspores. Arnold (1932) described a few spores along with other plant remains and fragments from the Upper Cretaceous and Tertiary coal of Greenland. Miner (1932) discovered nine megaspores from the Upper Cretaceous coals of western Greenland and described them under the name of Selaginellites. From the same collection Miner (1935a) described some fern sporangia,

wood fragments of Coniferales, cuticles, carpolithus, and small plant bodies that he called "Chrysotheca" (Miner). Hall (1967) reported that Chrysotheca Miner is a later homonym of Chrysotheka Doflein 1923 - a chrysophycean algae. He gave a new name of Costatheca Hall 1967, to Chrysotheca Miner 1935. Miner compared the Costatheca with the perianth of the Jungermaniales. He also described the genus Spermatites which may be primitive seeds that resemble the bryophytic antheridia. Some small spores, a bigger one, wood fragments, and cuticles from coal belonging to the Cretaceous and Tertiary of Montana have been described by Miner (1935b). Thirteen species of megaspores under the genus Triletes, four species of Costatheca, and one species each under Geleenites and Spherites have been described by Dijkstra (1949) from the Aachenian (Senonian) in South Limburg, The Netherlands. The affinities of the genus Geleenites are unknown, whereas the genus Spherites resembles the group Traquairiae and the Hystrichospheridae.

Schemel (1950) described four genera - Costatheca, Spermatites, Arcellites, and Molaspora - from the Crill coal bed in the Dakota (Cenomanian) of Plymouth County, Iowa (U.S.A.). Vangerow (1954) dealt with many megaspores and other plant microfossils from the Upper Cretaceous (Aachenian-Senonian) of Germany. He established the genus Microcarpolithes Vangerow for seeds or one-seeded fruits of small size without designating a type species for it. He described a number of species under this genus. Hall (1963) emended the genus Microcarpolithes and assigned M. hexagonalis Vangerow as its lectotype. He also described megaspores of Arcellites disciformis Miner, Molaspora lobata (Schemel) Hall, Balmeisporites auriculatus Hall, Minerisporites mirabilis (Miner) Potonié, Thomsonia dakotaensis Hall, and specimens of Costatheca,

Spermatites, and Microcarpolithes from the Dakota Formation of Iowa belonging to Cenomanian age. He speculated on the existence of a lake or bog environment during the deposition of these beds and noted the mixture of Upper and Lower Cretaceous floras in this area.

Kondinskaya (1966) described micro- and megaspores of Hydropteris Kondinskaya, Balmeisporites Cookson & Dettmann, and Pyrobolospora Potonié from the Upper Cretaceous and Paleogene deposits of the west Siberian lowland. Srivastava and Binda (1968) described Balmeisporites canadensis Srivastava & Binda, B. bellus Kondinskaya, B. dettmannii Srivastava & Binda, and B. kondinskaya Srivastava & Binda from the Upper Cretaceous sediments (Maestrichtian) of the western Canadian Plains. Binda (1967) described three species of Spermatites from shales of the Edmonton Formation and discussed their affinity with seeds of the modern genus Juncus.

Miner (1935a, b) proposed the genus Arcellites and designated cotypes only, not a holotype. Potter (1963) emended the genus Arcellites Miner 1935, but did not designate a lectotype. Ellis and Tschudy (1964) considered the emendation inadequate and emended it further. They designated A. disciformis as its type species. With the available data, they have noted that the genus Arcellites is restricted to the Lower Cretaceous and the lowermost Upper Cretaceous. They described its morphology and suggested the possible mode of function and habitat.

Hills and Weiner (1965), Stanley (1965), and Srivastava (1965, 1966, 1967) have noted the occurrence of Azolla in the Upper Cretaceous through the presence of microspores, massulae, and glochidia. Hills and Weiner (1965) also have described the megaspores of Azolla geneseana from the Upper Cretaceous Edmonton Formation of western Canada.

Hills and Gopal (1967) discussed the phylogenetic significance of A. primaeva. They favoured the theory of progressive simplification of glochidia and their ultimate elimination. Hall (1967) reported Azolla megaspores and massulae bearing several types of glochidia from Turonian and Campanian strata in U.S.A. Megaspores of Azolla intertrappea were described by Sahni and Rao (1943) from the Deccan Intertrappean beds. On the basis of the flora recovered, Sahni (1941) and Sahni and Rao (1943) supported the view that the Intertrappean beds in central India belong to the Early Tertiary rather than the Upper Cretaceous. Krishnan (1960) has discussed the age of these beds from the available data and has indicated that their age varies from the Upper Cretaceous to the Lower Eocene from place to place. It seems that Sahni (1941) was more inclined to put these beds in the Tertiary because of the presence of Nipa and Azolla in the recovered flora. Since Azolla has been noted from the definite Upper Cretaceous beds of North America and the Paleocene of Belgium (Dijkstra 1961), this suggests that the presence of Azolla in the Intertrappean beds of India may not necessarily restrict the age of these beds to the Tertiary Period.

The record of silicified megaspores in the literature is meager. This may be due to the extraction techniques where hydrofluoric acid is used freely to recover the organic remains by dissolving silica contents. Such a danger was noted by Sitholey (1943) while describing the plant remains from the Triassic of the Salt Range (now in West Pakistan). Sahni and Rao (1943) have described the silicified flora from the Intertrappean cherts of central India, which included megaspores also. Sahni (1941) had speculated on the yield of silicified plant remains from the inter-basaltic freshwater deposits of northwestern Britain and

North America. Binda and Srivastava (1968) have reported many silicified megaspores with well preserved wall structure from the bentonitic shales of southern Alberta (Canada). They have described nine species belonging to five form-genera: Henrisporites, Verrutriletes, Horstisporites, Stelckisporites, and Selenasporites. The genera Henrisporites and Verrutriletes are emended. The morphologic similarity of these megaspores with those of Lycopodiales, Selaginellaceae, and Isoetes has been suggested, and may indicate possible paleoecological conditions prevailing during the deposition of these beds.

UPPER CRETACEOUS MICROPLANKTONS

Sarjeant (1961) discussed and reviewed the literature and classification of the hystrichospheres and has included most of the earlier work in the bibliography. Further microplanktons have been described by Cookson and Eisenack (1960a, b, 1961, 1962) from the Cretaceous sediments of Australia. Evitt (1964) discussed the characters of dinoflagellates and their use in petroleum geology. Downie and Sarjeant (1964) gave a comprehensive bibliography and index of fossil dinoflagellates and acritarchs. Norris and Sarjeant (1965) reviewed all genera of fossil microplanktons belonging to Dinophyceae and Acritarcha. They emended the genera formally where necessary. The names applied to fossil microplanktonic forms are also listed. The original references to generic diagnoses and number of constituent species of each genus are also included. Sarjeant and Downie (1966) gave the classification of dinoflagellate cysts above the generic level on the basis of morphologic differences among the cysts. The cyst-families suggested by the authors may not be in accordance with the International Code of Botanical

Nomenclature which at present does not recognize form-groupings above the generic level.

Davey, Downie, Sarjeant and Williams (1966) did a comprehensive study of dinoflagellate cysts from Mesozoic and Cainozoic strata. Clarke and Verdier (1967) described microplankton assemblages from chalk surface samples of Cenomanian to Senonian age from Isle of Wight, England. The samples were collected from two sections which were already well dated upon independent paleontological evidence. They diagnosed four genera viz. Ellipsodinium, Clarke and Verdier, Hexasphaera Clarke and Verdier, Pyramidium Clarke and Verdier and Senoniasphaera Clarke and Verdier and described 21 species. A few of these species are junior synonyms of the species described by Davey et al. (1966). These have been listed by Clarke et al. (in press).

APPENDIX B

FORMAL DESIGNATION OF NEW MEMBERS

THE TOLMAN MEMBER (new)

The Tolman Member is hereby named and formally designated as a member in the middle Edmonton division of the Edmonton Formation.

NAME: The Tolman Member derives its name from the Tolman Crossing about 1½ miles north of the section measured. (Betty Tolman section of thesis).

TYPE AREA: Tolman Crossing of Red Deer River, sec. 12, twp. 33, rge. 22, W. 4th Mer., Alberta, Canada.

DEFINITION: The Tolman Member overlies the uppermost bed of the Drumheller Member of the lower Edmonton division in the Edmonton Formation. It underlies the first coal seam in the middle Edmonton division occurring about 260 feet above the water-level of the Red Deer River in the Betty Tolman section of the thesis. The Tolman Member consists of sandstones and siltstones with some admixture of calcareous and ferruginous matter. The average thickness of the Tolman Member is 130 feet in the Red Deer River Valley. Dinosaur remains have been located in the lower strata of this member.

The lithological details of the Tolman Member are shown in the stratigraphic section given in Figure 13.

DISTINGUISHING CHARACTERISTICS: The Tolman Member can be distinguished from the underlying Drumheller Member in lacking the brackish elements and from the overlying coaly member by lack of coaly beds.

BOUNDARIES: The base of the Tolman Member is marked by the base of a thin two-foot ironstone bed about 135 feet above the water-level of the Red Deer River at Tolman Crossing. The top of this member is marked by the base of the five-foot thick coal seam about 260 feet above the water-level of the Red Deer River at Tolman Crossing.

GEOLOGIC AGE: Upper Cretaceous (Maestrichtian).

THE NEVIS MEMBER (new)

The Nevis Member is here named and formally designated as a member of the upper Edmonton division of the Edmonton Formation.

NAME: The Nevis Member derives its name from the town Nevis near the type section in Alberta.

TYPE AREA: Red Deer River, Huxley region, sec. 13, twp. 34, rge. 22, W. 4th Mer., Alberta, Canada (see Snead 1968, p. 156).

DEFINITION: The Nevis Member overlies the mammal-bearing member of the upper Edmonton division in the Edmonton Formation and underlies unconformably the Paskapoo Formation. Lithologically, the Nevis Member is composed of lignites, coal seams, claystones, siltstones and sandstones. For detailed lithologic description see Snead (1968, p. 156). The maximum thickness of the Nevis Member in the Scollard area is 140 feet. At the type area in the Huxley region, this member is 82 feet thick.

DISTINGUISHING CHARACTERISTICS: The Nevis Member can be distinguished from the underlying mammal-bearing member and the overlying Paskapoo Formation by the contained coal seams.

BOUNDARIES: The base of the Nevis Member is at the base of one-foot thick argillaceous, dark grey to black lignite overlying a twenty-foot medium-grained, grey, loosely consolidated sandstone bed. The top of this member is a five-foot thick silty, light grey to buff, and carbonaceous claystone underlying a thirteen-foot sandstone bed (basal Paskapoo). The bottom is fine- to medium-grained, grey, buff weathering with some cross-bedding, and carbonaceous material near base.

GEOLOGIC AGE: Upper Cretaceous - Paleocene (?).

PLATE I

(All figures magnified X 1,000 unless otherwise mentioned).

1-7	Liliacidites mirus n. sp.; fig. 1 (Holotype) proximal view; fig. 2 (Holotype) distal view; fig. 3 Isotype; fig. 4 Isotype; fig. 5 Isotype; figs. 6, 7 Isotype	p. 83
8	Liliacidites morrinensis n. sp. (Holotype)	p. 84
9	Liliacidites variegatus Couper 1953	p. 85

PLATE I

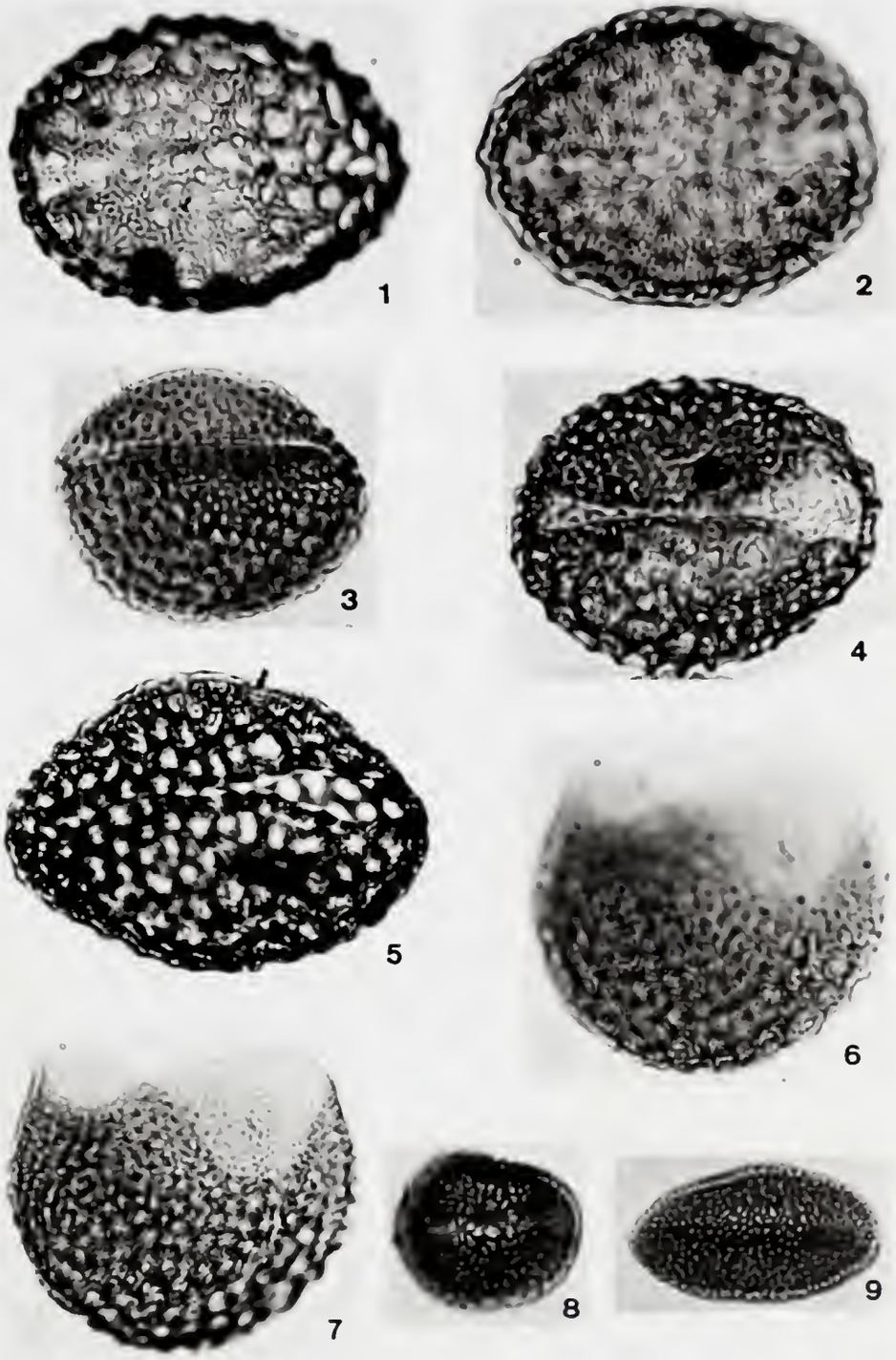


PLATE II

(All figures magnified X 1,000 unless otherwise mentioned)

1	Rhoipites crassus Stanley 1965	p. 86
2, 3	Alnipollenites speciipites Woodhouse 1933; fig. 2 tetraporate pollen, fig. 3 pentaporate pollen	p. 87
4	Erdtmanipollis albertensis n. sp. (Holotype)	p. 90
5, 6	Erdtmanipollis procumbentiformis (Samoilovitch in Samoilovitch and Mtchedlishvili) n. comb.; fig. 5 equatorial margin of pollen in focus, fig. 6 central portion of pollen in focus showing crotonoid ornamentation	p. 91
7, 8	Carpinites ancipites (Wodehouse) Srivastava 1966	p. 92
9, 10	Polyporina cribraria n. sp. (Holotype); fig. 9 equatorial margin of pollen in focus, fig. 10 central portion of pollen in focus	p. 93
11	Coriaripites alienus n. sp. (Holotype)	p. 96
12, 13	Faguspollenites granulatus (Martin and Rouse) n. comb.	p. 97
14, 15	Quercoidites sternbergii Srivastava 1966	p. 98

PLATE II

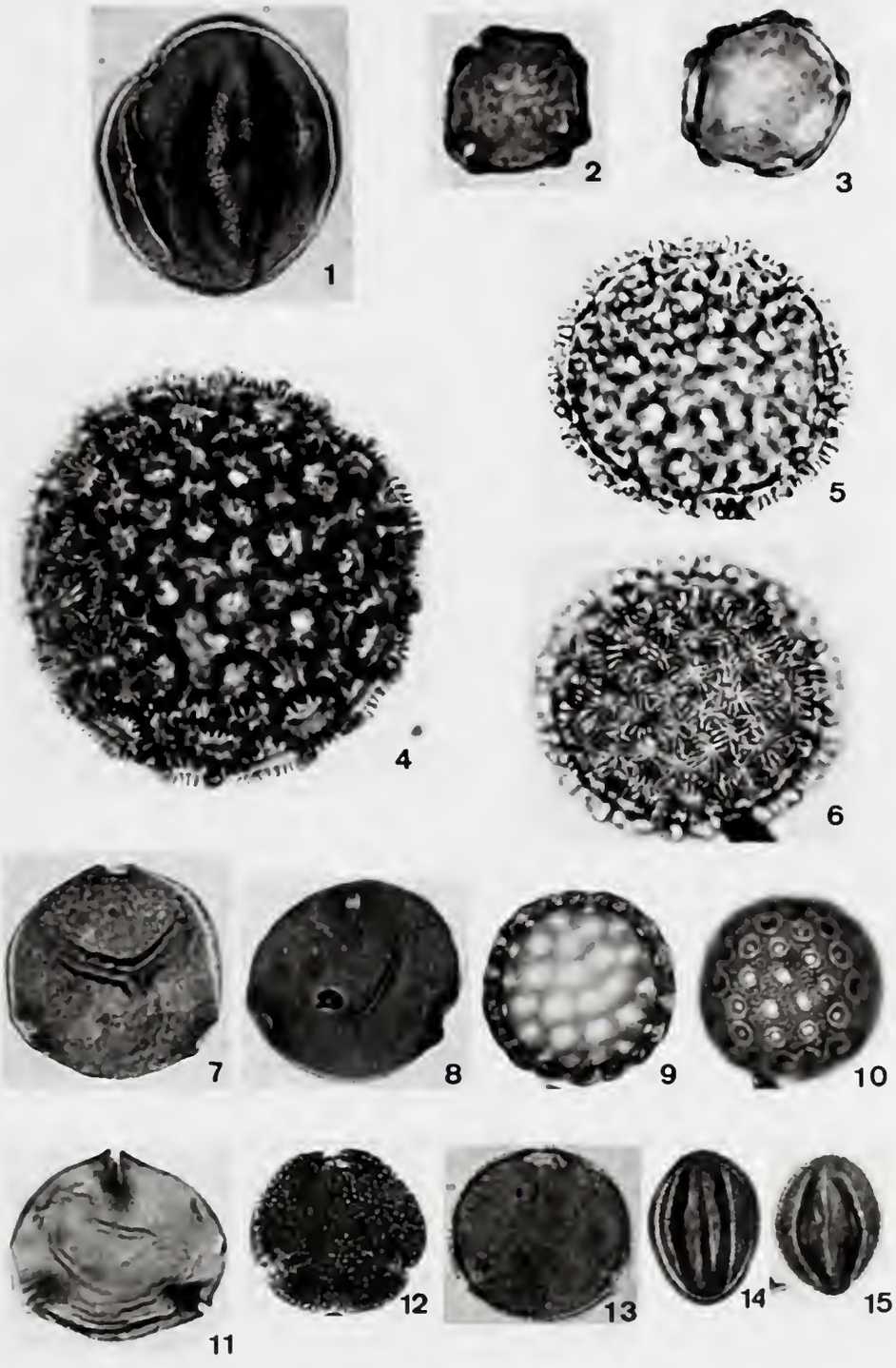


PLATE III

(All figures magnified X 1,000 unless otherwise mentioned)

1	*Ilexpollenites obscuricostatus* (Traverse) Srivastava 1966	p. 99
2, 3	*Caryapollenites paleocenicus* (Stanley) n. comb.	p. 100
4	*Cranwellia asperata* n. sp. (Holotype)	p. 102
5	*Cranwellia rumseyensis* Srivastava 1966	p. 103
6	*Cranwellia bacata* n. sp. (Holotype)	p. 103
7, 8	*Cranwellia edmontonensis* Srivastava 1966	p. 104
9	*Cranwellia fida* n. sp. (Holotype)	p. 105
10, 11	*Loranthacites pilatus* Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961	p. 107
12	*Myricipites dubius* Wodehouse 1933	p. 109
13	*Zonosulcites scollardensis* n. sp. (Holotype)	p. 110
14	*Zonosulcites parvus* n. sp. (Holotype)	p. 110
15, 16	*Nyssapollenites parvus* n. sp.; fig. 15 Isotype; fig. 16 Holotype	p. 111
17	*Nyssapollenites bindae* n. sp. (Holotype)	p. 112

PLATE III

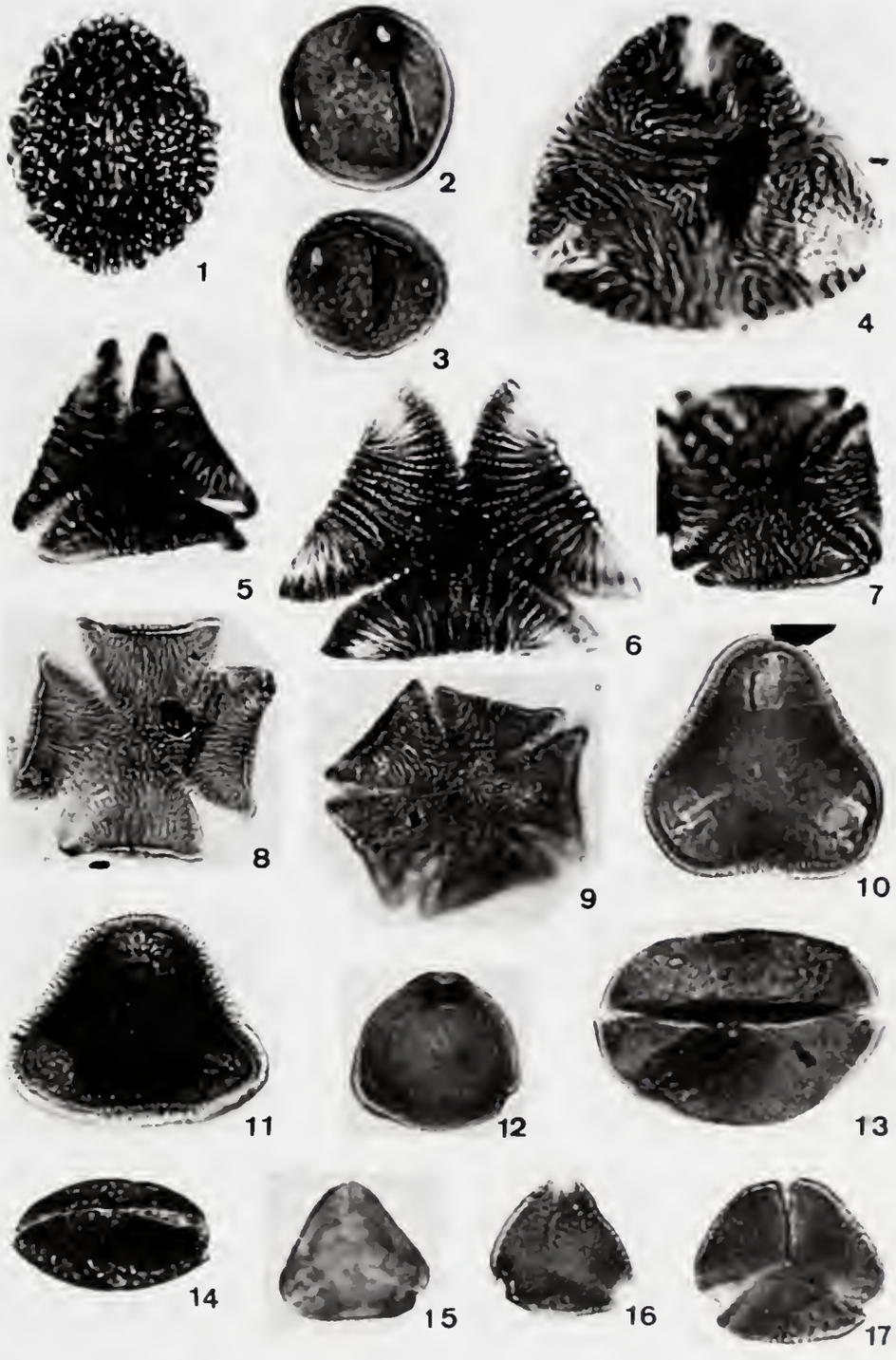


PLATE IV

(All figures magnified X 1,000 unless otherwise mentioned)

1, 2	Nyssoidites edmontonensis n. sp. (Holotype)	p. 113
3	Nyssoidites ingentipollinus (Traverse) Potonié 1960	p. 114
4	Anacolosidites insignis Samoilovitch in Mtchedlishvili and Samoilovitch 1960	p. 115
5	Fraxinoipollenites variabilis Stanley 1965	p. 117
6-11	Beaupreaidites angulatus (Samoilovitch in Samoilovitch and Mtchedlishvili) n. comb.; fig. 6 X 500, fig. 7 details of sexine and aperture of the same; fig. 8 X 500, fig. 9 details of sexine and aperture of the same; fig. 10 X 500, fig. 11 details of sexine and aperture of the same	p. 122

PLATE IV

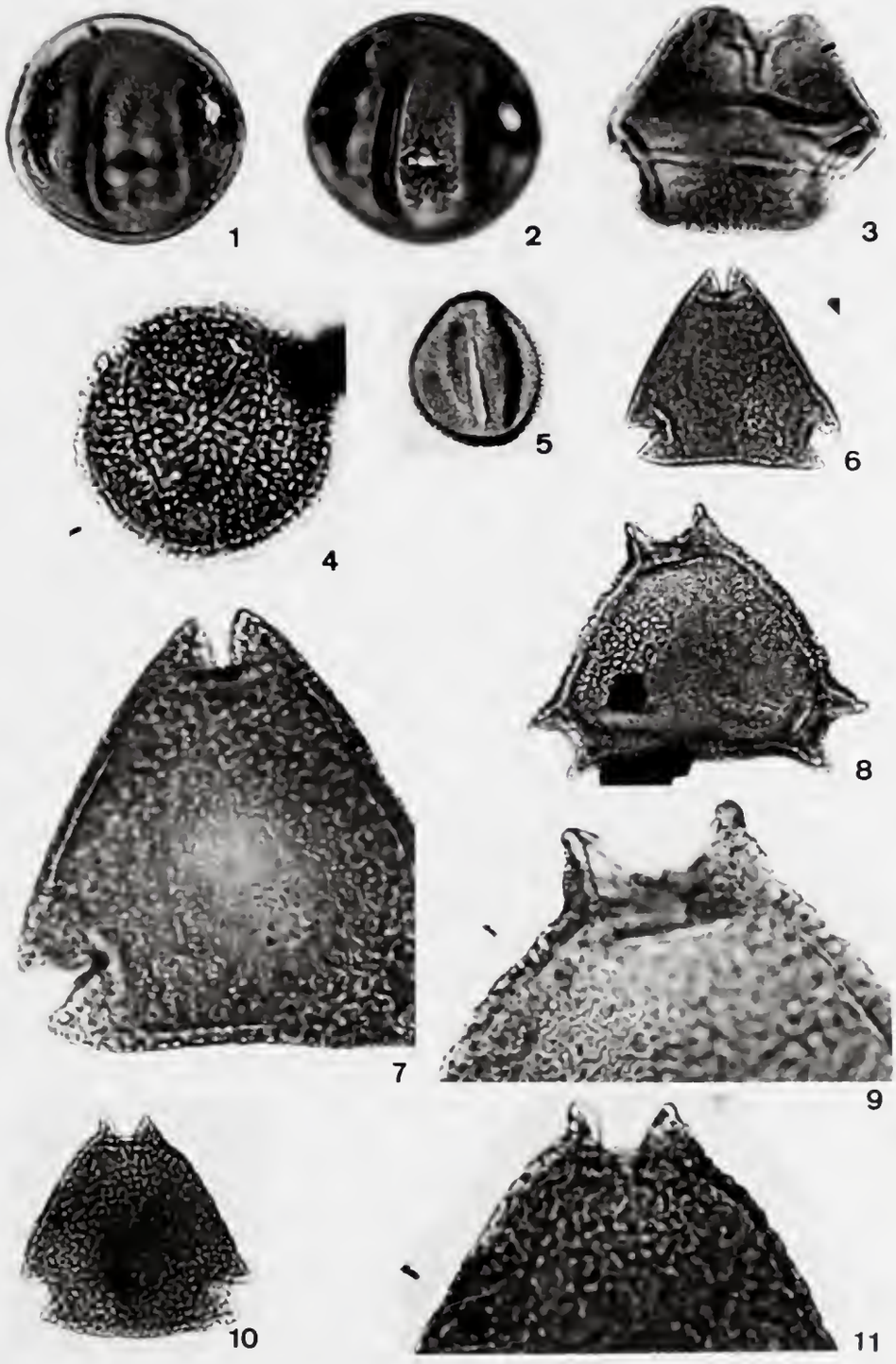


PLATE V

(All figures magnified X 1,000 unless otherwise mentioned)

1-5 Beaupreaidites angulatus (Samoilovitch in Samoilovitch and Mtchedlishvili) n. comb; fig. 1 X 500; figs. 2, 3 details of sexine and aperture of the same; fig. 4 X 500, fig. 5 details of sexine and aperture of the same p. 122

6-8 Beaupreaidites occulatus (Samoilovitch in Samoilovitch and Mtchedlishvili) n. comb. fig. 6 X 500, figs. 7, 8 details of the same in different foci p. 123

9 Beaupreaidites libitus n. sp. p. 124

PLATE V

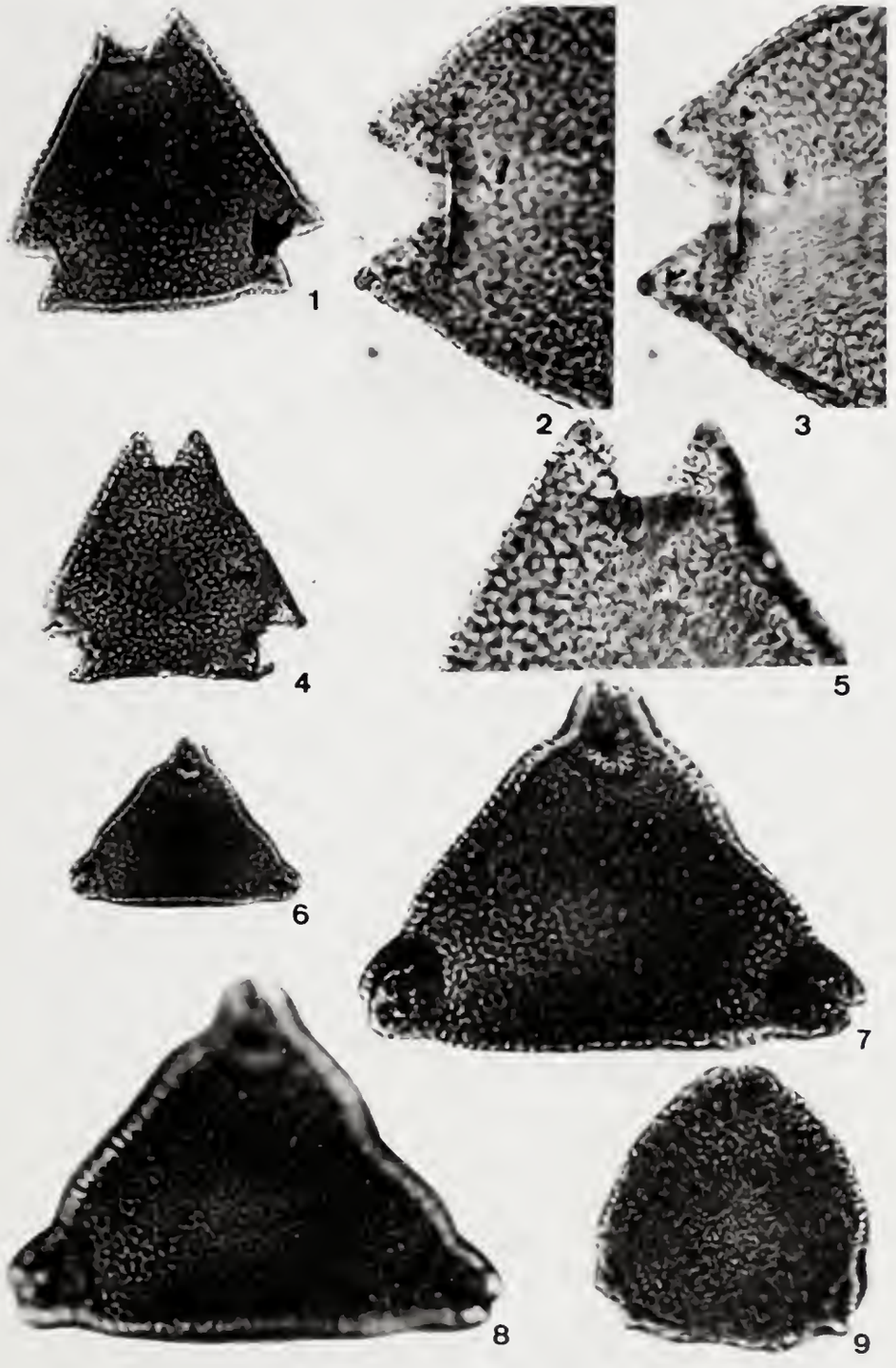


PLATE VI

(All figures magnified X 1,000 unless otherwise mentioned)

1-3	Beaupreaidites libitus n. sp. (Holotype), fig. 1 X 500, figs. 2, 3 details of the same in different foci	p. 124
4	Proteacidites auratus n. sp. (Holotype)	p. 126
5-7	Proteacidites thalmannii Anderson 1960, figs. 6, 7 same specimen in different foci	p. 127
8, 9	Proteacidites tumidiporus var. ecollariatus Samoilovitch in Samoilovitch and Mtchedlishvili 1961, same specimen in different foci	p. 128
10	Rhamnacidites minutapollenites (Rouse) n. comb.	p. 130
11	Talisiipites fischeri Wodehouse 1933	p. 131

PLATE VI

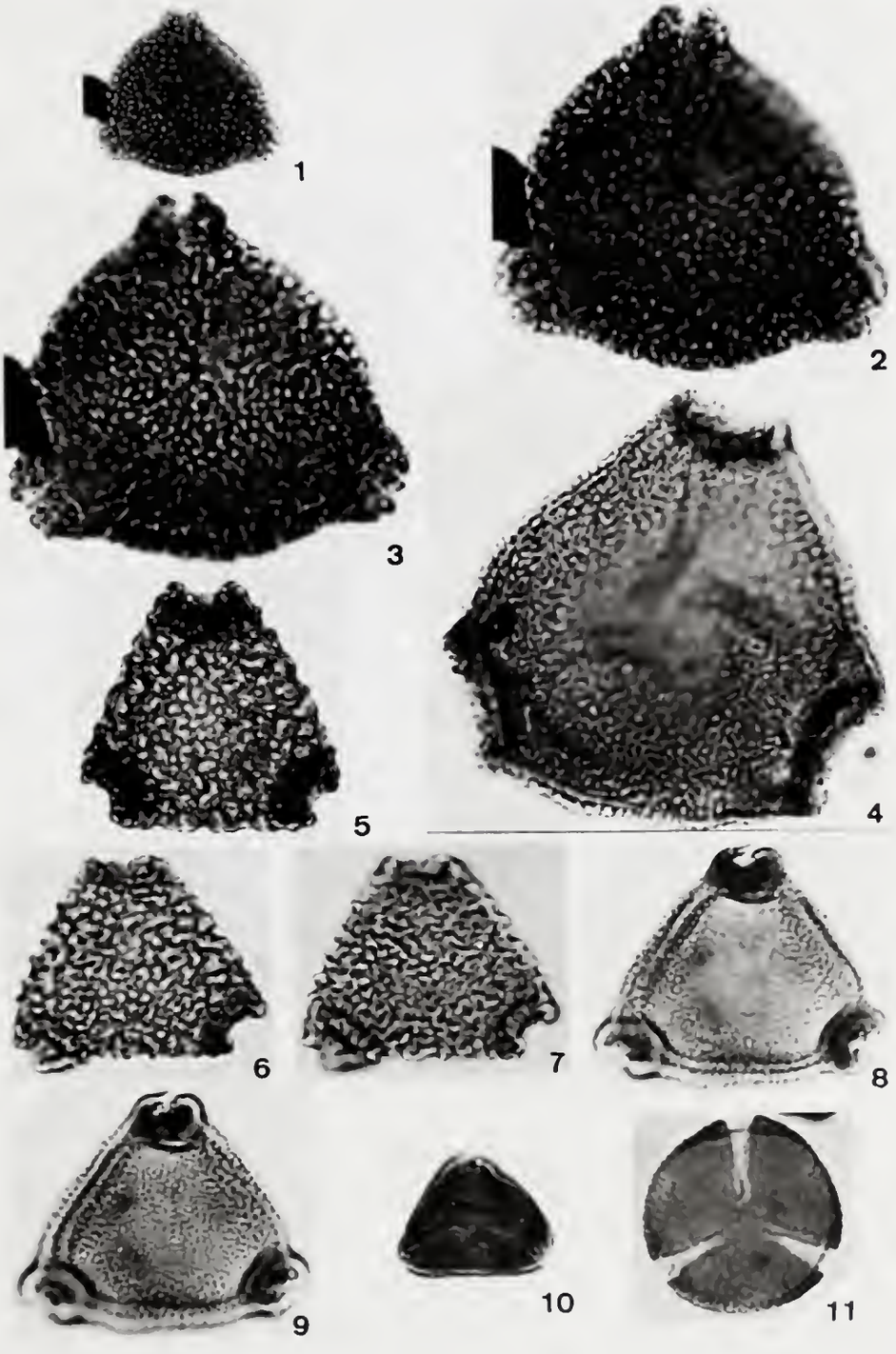


PLATE VII

(All figures magnified X 1,000 unless otherwise mentioned)

1	Rousea subtilis n. sp. (Holotype)	p. 132
2, 3	Ailanthipites cupidineus n. sp. (Holotype), in different foci	p. 134
4	Ailanthipites potoniei n. sp. (Holotype)	p. 134
5	Symplocoipollenites morrinensis n. sp. (Holotype)	p. 136
6	Ulmipollenites planeraeformis (Anderson) n. comb.	p. 137
7	Monosulcites drumhellerensis n. sp. (Holotype)	p. 138
8	Monosulcites echinatus n. sp. (Holotype)	p. 139
9	Monosulcites gemmatus Couper 1960	p. 140
10, 11	Disulcites magnus n. sp. (Holotype), fig. 10 details of sexine ornamentation, fig. 11 X 500	p. 141
12	Nothopollenites primus n. sp. (Holotype)	p. 142

PLATE VII

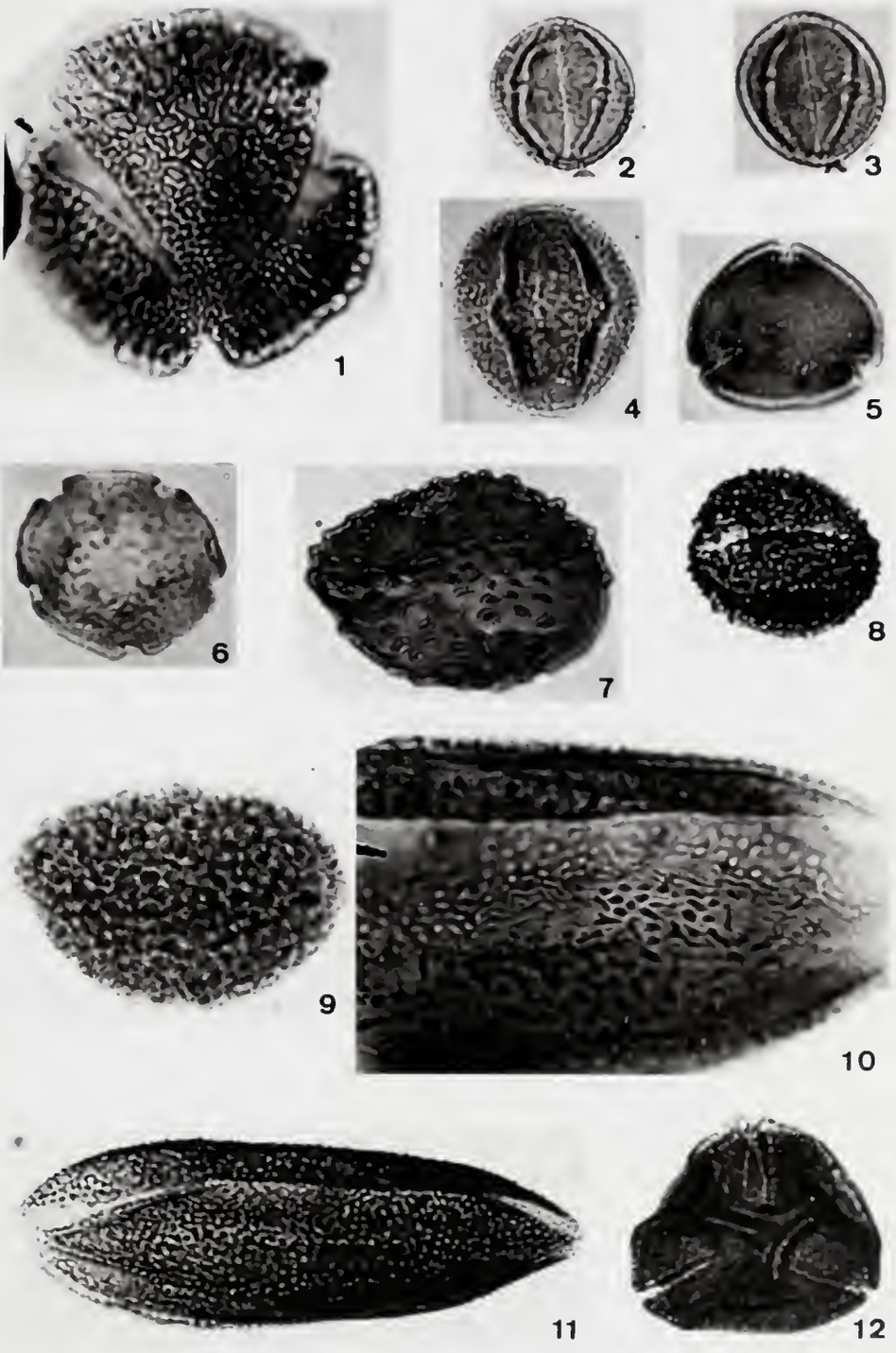


PLATE VIII

(All figures magnified X 1,000 unless otherwise mentioned)

1-3	Trifossapollenites ellipticus Rouse 1957	p. 144
4-7	Albertipollenites rosalindii n. sp.; figs. 4, 5 (Holotype) in different foci; figs. 6, 7 Isotype in different foci	p. 145
8, 9	Tricolpites microreticulatus Belsky, Boltenhagen and Potonie' 1965	p. 148
10	Tricolpites mtchedlishviliae (Lubomirova) n. comb.	p. 149
11	Tricolpites occidentalis n. sp. (Holotype)	p. 150
12-15	Tricolpites vulgaris (Pierce) n. comb.	p. 151

PLATE VIII

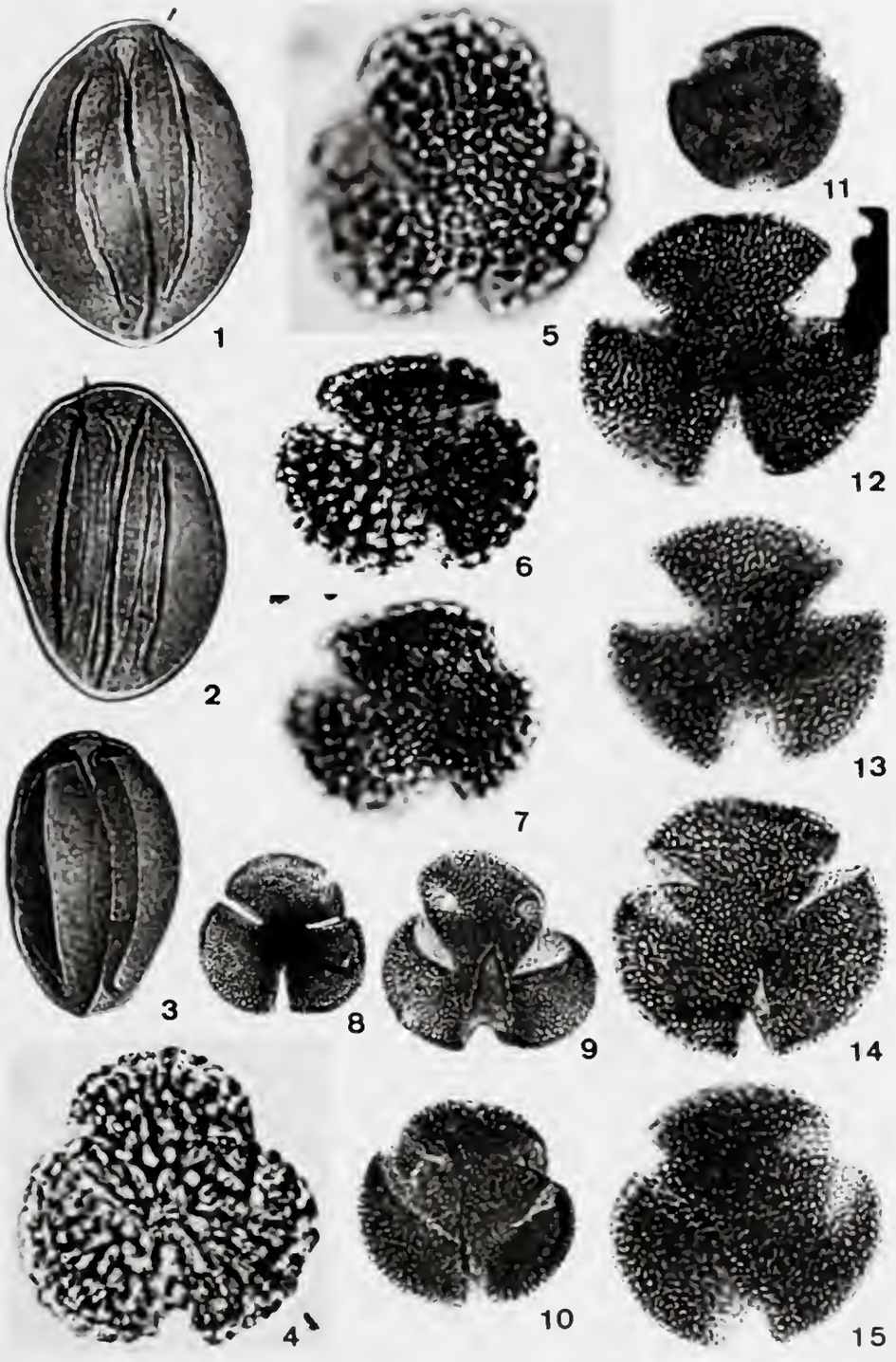
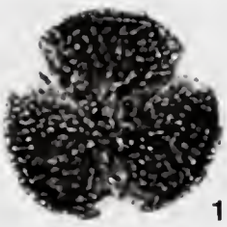


PLATE IX

(All figures magnified X 1,000 unless otherwise mentioned)

1, 2	*Margocolporites taylorii* n. sp. (Holotype) in different foci	p. 152
3	*Stelckia vera* n. sp. (Holotype)	p. 154
4	*Stelckia unica* n. sp. (Holotype)	p. 154
5	*Stelckia xenoforma* n. sp. (Holotype)	p. 155
6	*Tubulifloridites aedicula* n. sp. (Holotype)	p. 156
7	*Grewipollenites canadensis* n. sp. (Holotype)	p. 157
8-10	*Pulcheripollenites narcissus* n. sp. (Holotype); fig. 8 X 500, figs. 9, 10 details of sexine in different foci	p. 158
11	*Pulcheripollenites inrasus* n. sp. (Holotype)	p. 159

PLATE IX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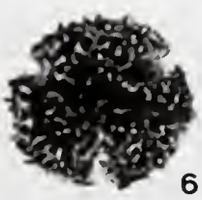
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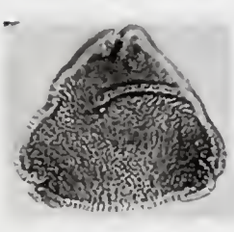
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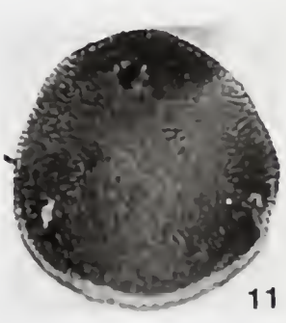
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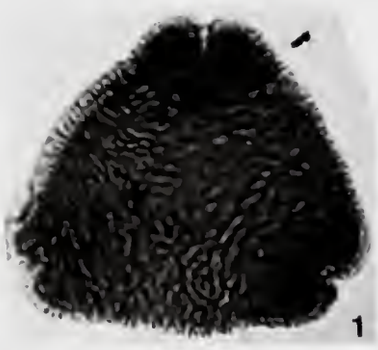
PLATE X

(All figures magnified X 1,000 unless otherwise mentioned)

1-4	Pulcheripollenites krempii n. sp.; figs. 1, 2 (Holotype) in different foci; fig. 3 Isotype; fig. 4 Isotype	p. 160
5, 6	Scollardia trapaformis Srivastava 1966	p. 162
7, 8	Scollardia steevesii Srivastava 1966	p. 163

PLATE X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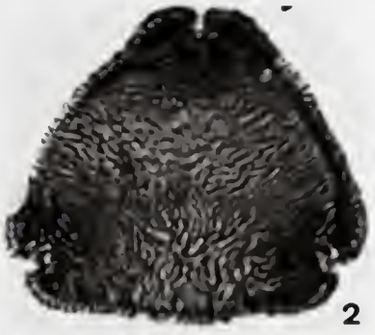
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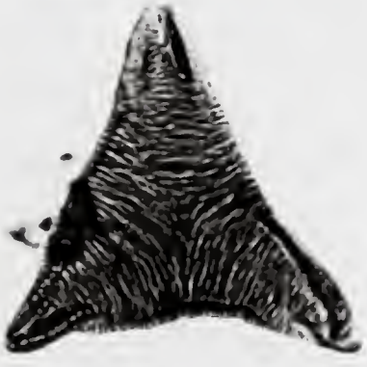
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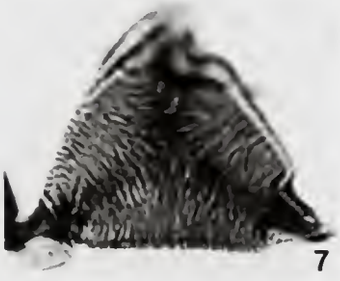
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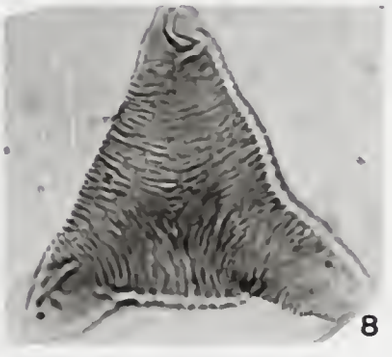
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PLATE XI

(All figures magnified X 1,000 unless otherwise mentioned)

1, 2	Scollardia nortonii Srivastava 1966	p. 163
3-5	Senipites drumhellerensis n. sp.; fig. 3 Holotype; fig. 4 Isotype; fig. 5 Isotype	p. 165
6-8	Wilsonipites nevisensis n. sp.; fig. 6 Holotype; fig. 7 Isotype, equatorial view; fig. 8 Isotype	p. 166
9-11	Callistopollenites radiatostriatus (Mtchedlishvili in Samoilovitch and Mtchedlishvili) n. comb.	p. 168
12	Callistopollenites comis n. sp. (Holotype)	p. 169

PLATE XI

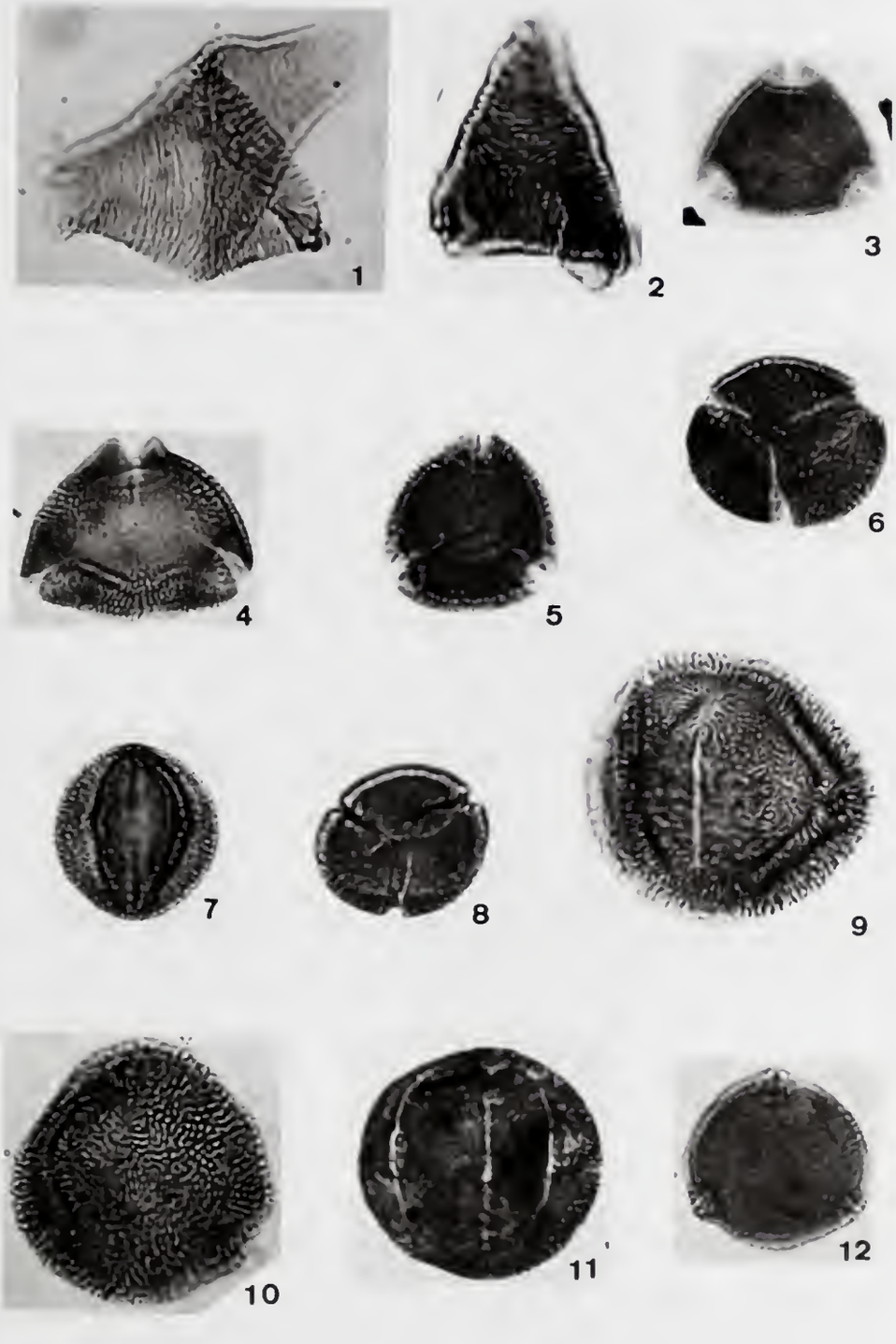


PLATE XII

(All figures magnified X 1,000 unless otherwise mentioned)

1-3	Callistopollenites tumidoporus n. sp.; figs. 1, 2 Holotype in different foci; fig. 3 Isotype showing swollen apertural areas	p. 170
4	Tetracolpites pulcher n. sp. (Holotype)	p. 171
5	Erdtmania superba n. sp. (Holotype)	p. 172
6	Scabrastephanocolpites albertensis n. sp. (Holotype)	p. 174
7	Scabrastephanocolpites lepidus n. sp. (Holotype)	p. 174
8	Marcellopites tolmanensis n. sp. (Holotype)	p. 175
9	Marcellopites basilicus n. sp. (Holotype)	p. 176
10	cf. Orbiculapollis globossus (Chlonova) Chlonova 1961	p. 177

PLATE XII

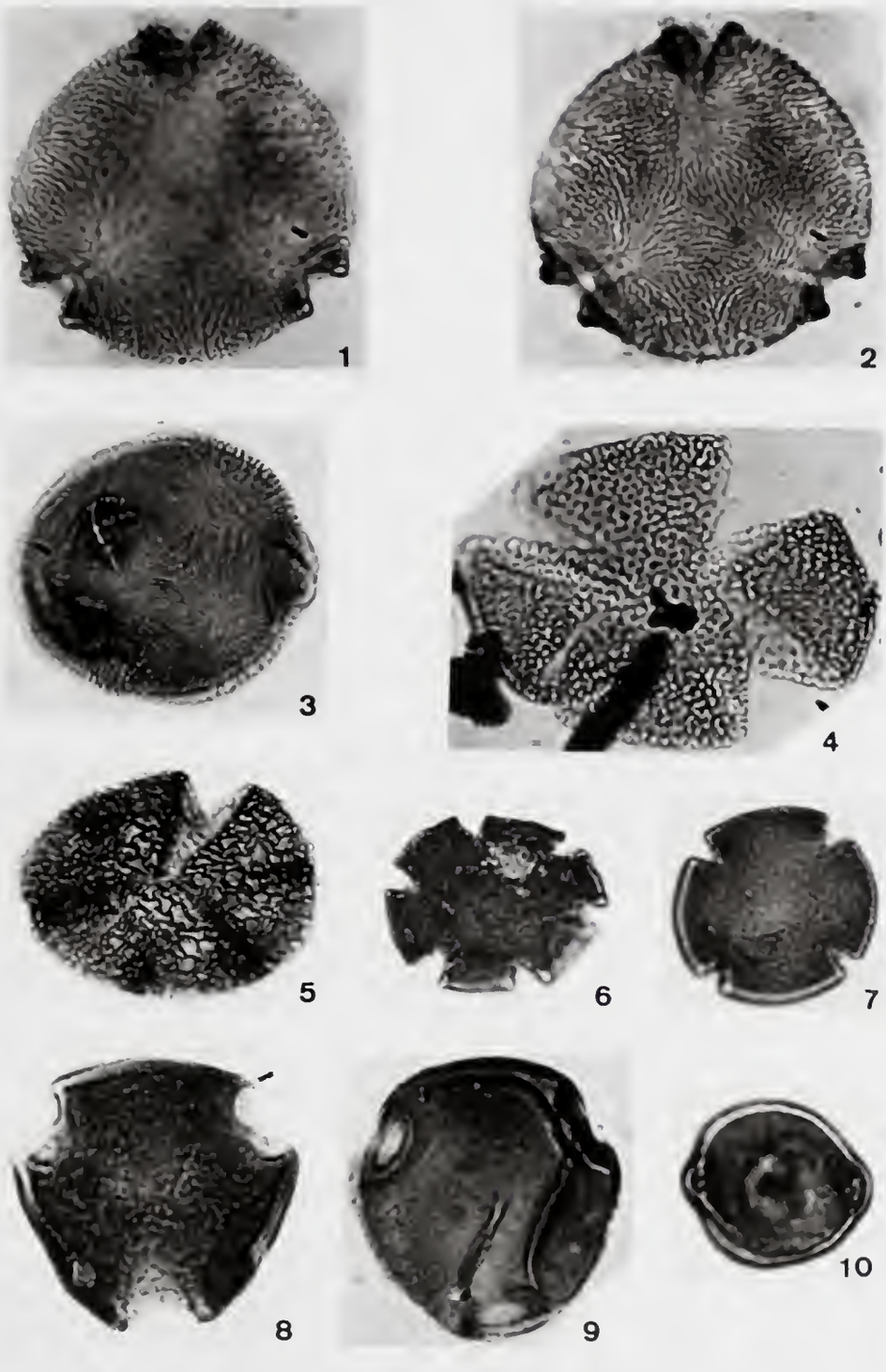


PLATE XIII

(All figures magnified X 1,000 unless otherwise mentioned)

1-6 Aquilapollenites accipiteris n. sp.; fig. 1 X 500 Holotype, fig. 2 details of holotype showing sexine structure on one of the poles and a colpus on one of the equatorial projections, fig. 3 details of holotype in another focus, showing sexine ornamentation on equatorial projection and body, fig. 4 X 500 Isotype, fig. 5 details of isotype showing sexine structure on one of the polar projections and a colpus across one of the equatorial projections, fig. 6 details of isotype in another focus showing sexine ornamentation on equatorial projection and body p. 181

PLATE XIII

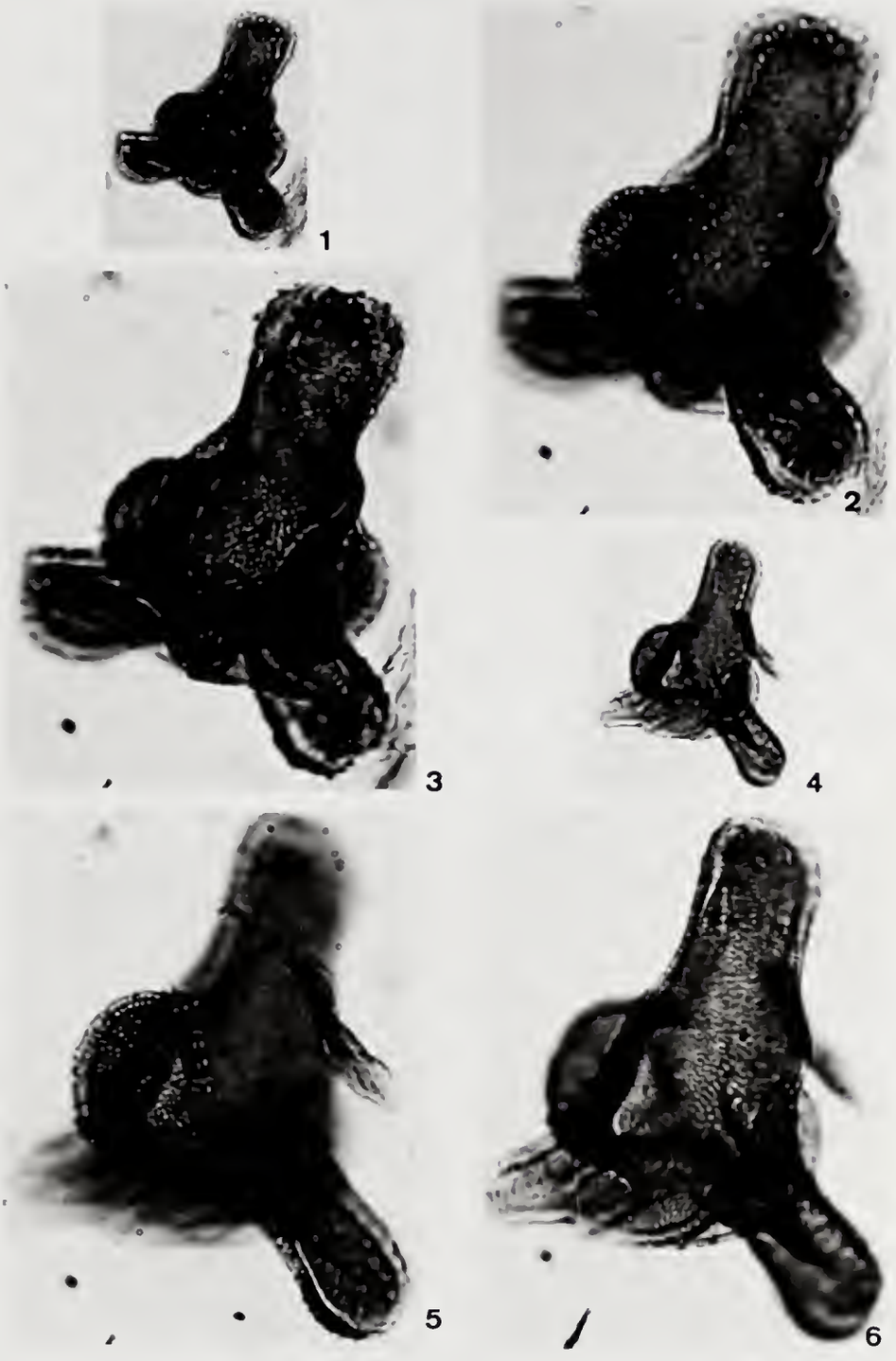
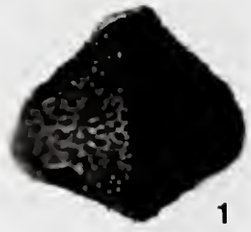


PLATE XIV

(All figures magnified X 1,000 unless otherwise mentioned)

1, 2	Aquilapollenites aptus n. sp. (Holotype) in different foci	p. 184
3	Aquilapollenites argutus n. sp. (Holotype)	p. 185
4-7	Aquilapollenites ascriptivus n. sp. (Holotype), fig. 4 X 500; figs. 5, 6, 7 serial microphotographs showing details of sexine at different parts of pollen, fig. 7 shows a colpus across one of the equatorial projections	p. 186

PLATE XIV



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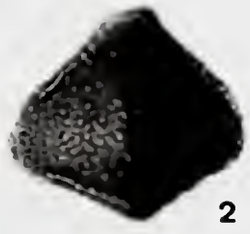

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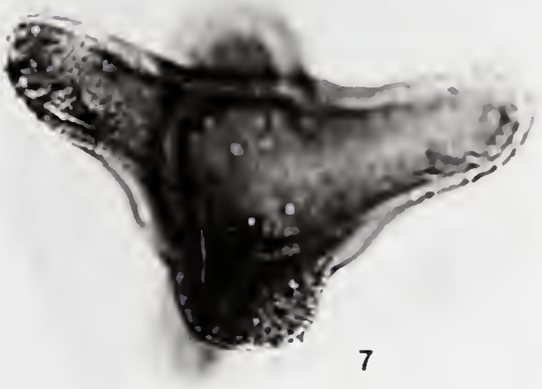

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PLATE XV

(All figures magnified X 1,000 unless otherwise mentioned)

1, 2 Aquilapollenites aucellatus n. sp. (Holotype) in different foci p. 187

3-6 Aquilapollenites augustus n. sp.; fig. 3 X 500 Holotype, fig. 4 details of holotype showing sexine sculpture on equatorial projections, fig. 5 details of holotype showing sexine sculpture on polar projections and body; fig. 6 X 500 Isotype p. 189

PLATE XV

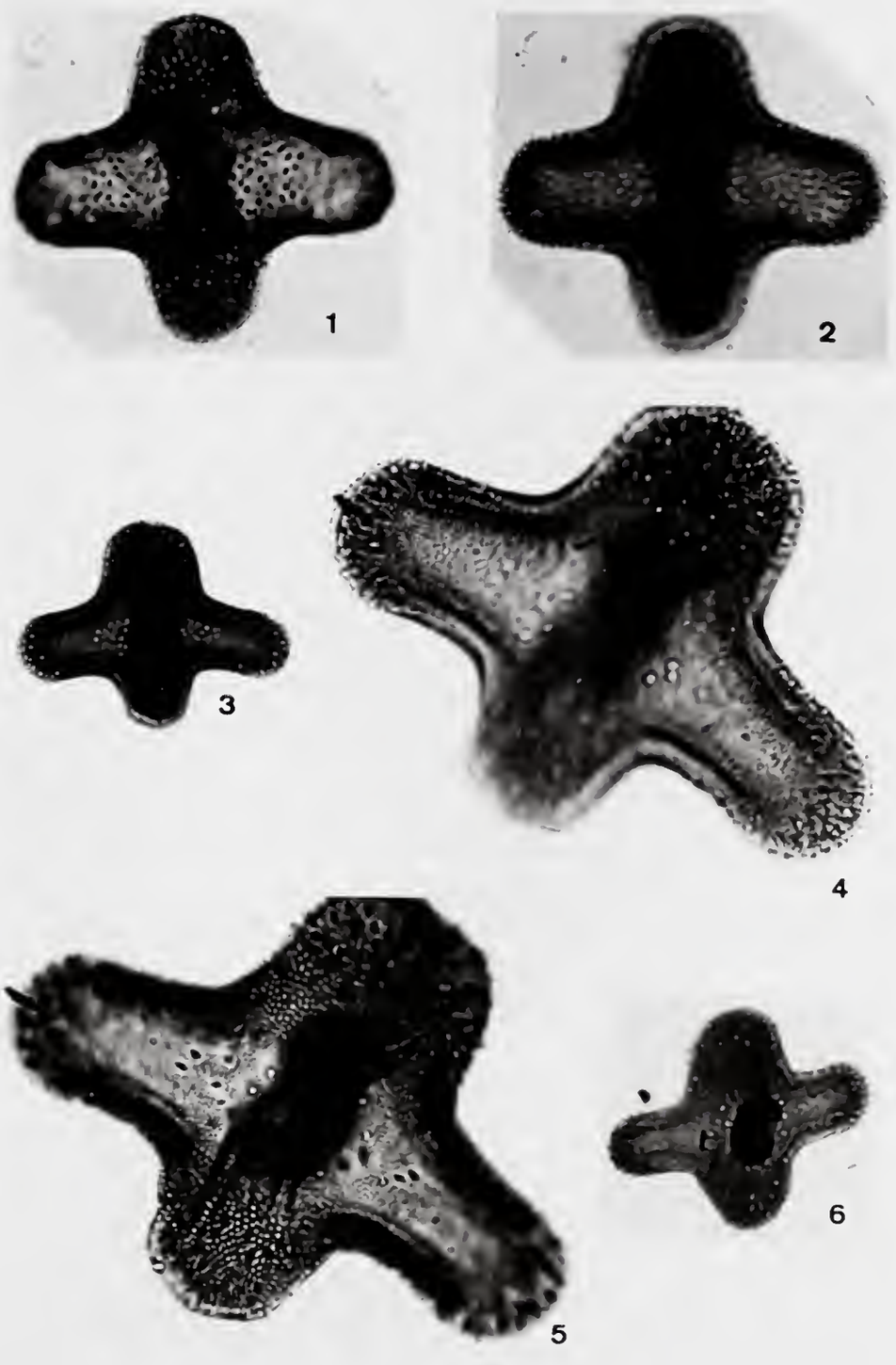

PLATE XVI

(All figures magnified X 1,000 unless otherwise mentioned)

1-4 *Aquilapollenites augustus* n. sp.; fig. 1 X 500 Isotype, fig. 2 Isotype showing one of the colpi across the equatorial projection; fig. 3 X 500 Isotype, fig. 4 Isotype showing details of sexine structure p. 189

5 *Aquilapollenites* barbatus n. sp. (Holotype) p. 190

6 *Aquilapollenites comosus* n. sp. (Holotype) p. 191

7 *Aquilapollenites drumhellerensis* n. sp. (Holotype) p. 192

8 *Aquilapollenites firmus* n. sp. (Holotype) p. 194

PLATE XVI

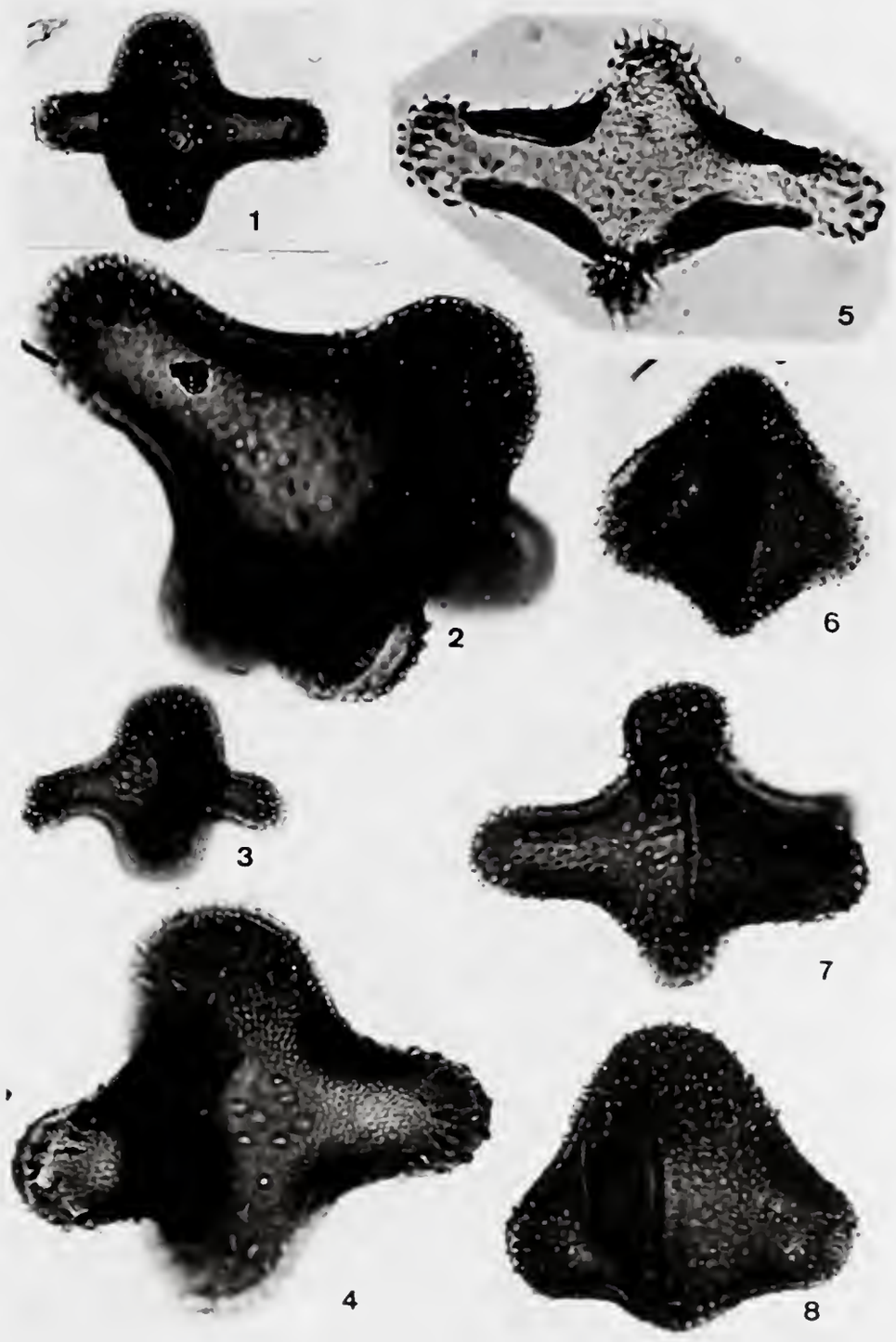

PLATE XVII

(All figures magnified X 1,000 unless otherwise mentioned)

1	Aquilapollenites hirsutus n. sp. (Holotype)	p. 195
2, 3	Aquilapollenites hispidus n. sp. (Holotype), fig. 2 X 500, fig. 3 details showing sexine sculpture	p. 196
4-7	Aquilapollenites paplionis n. sp.; figs. 4, 5 Isotype in different foci; fig. 6 Holotype; fig. 7 Isotype	p. 197

PLATE XVII

PLATE XVIII

(All figures magnified X 1,000 unless otherwise mentioned)

1-3	Aquilapollenites petasus n. sp. (Holotype), fig. 1 X 500, fig. 2 showing details of equatorial projections, fig. 3 showing details of polar projection	p. 199
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5	Aquilapollenites pumilis n. sp. (Holotype)	p. 201
6, 7	Aquilapollenites regalis n. sp. (Holotype), fig. 6 X 500, fig. 7 showing details of polar projection and one colpus across the equatorial projection	p. 202

PLATE XVIII

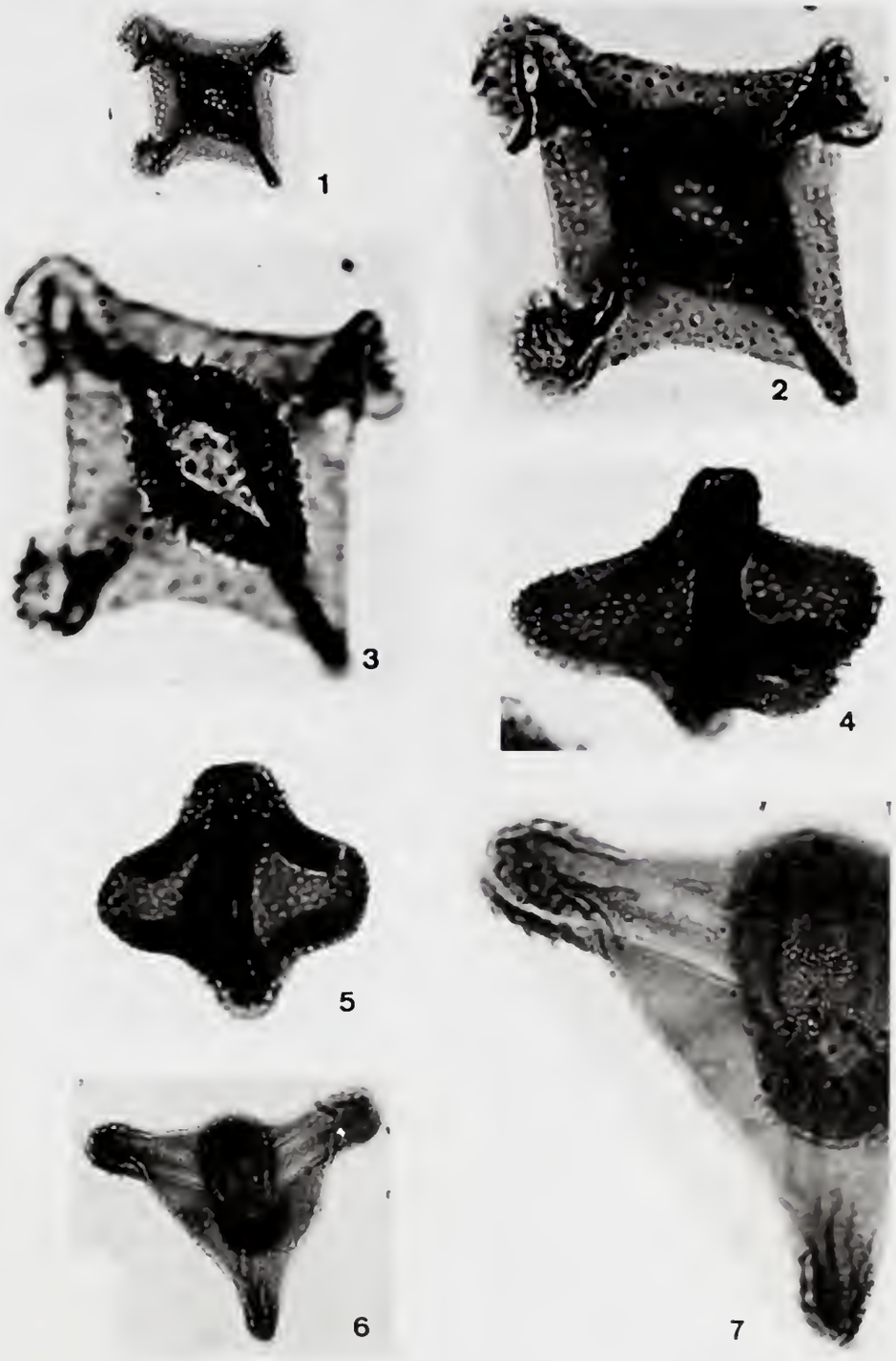


PLATE XIX

(All figures magnified X 1,000 unless otherwise mentioned)

1-5 Aquilapollenites sentus n. sp.; fig. 1 X 500 Holotype, fig. 2 details of holotype; fig. 3 Isotype, fig. 4 X 500 same as fig. 3; fig. 5 Isotype p. 203

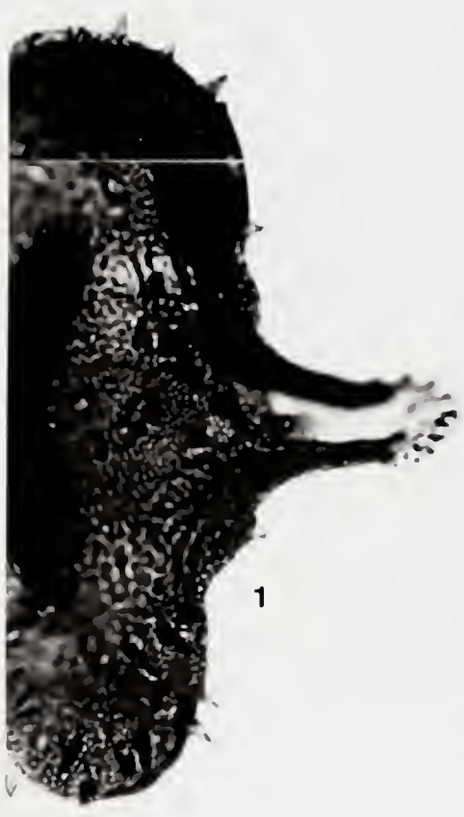
PLATE XIX

PLATE XX

(All figures magnified X 1,000 unless otherwise mentioned)

1-5 Aquilapollenites sentus n. sp.; fig. 1 Isotype, fig. 2 X 500; figs. 3, 4, 5 Isotype in different foci p. 203

PLATE XX



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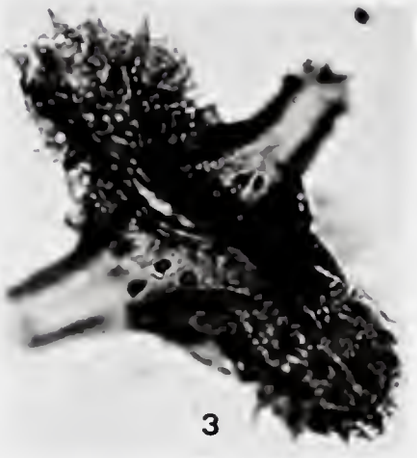

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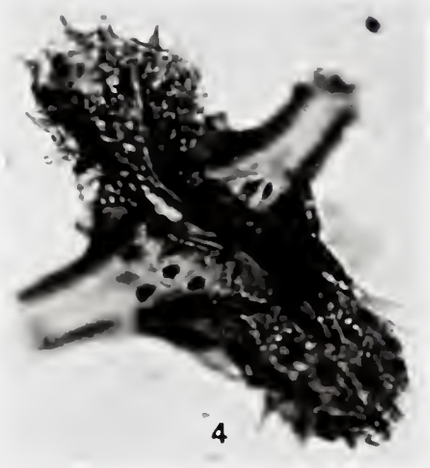

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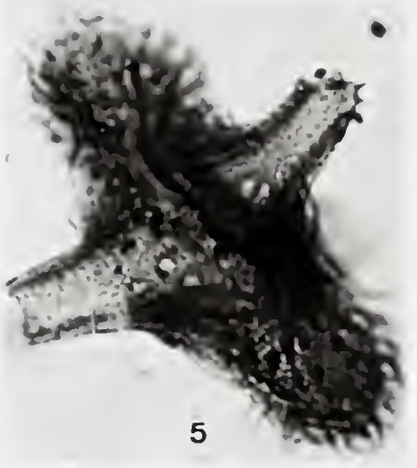

5

PLATE XXI

(All figures magnified X 1,000 unless otherwise mentioned)

1, 2 Aquilapollenites stellatus n. sp. (Holotype), fig. 1 X 500, fig. 2 details of holotype showing sexine sculpture p. 205

3, 4 Aquilapollenites amplus Stanley 1961 in different foci p. 206

5-7 Aquilapollenites asper Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961, fig. 5 showing details of sexine at one polar projection, fig. 6 X 500, fig. 7 showing details of sexine at equatorial projections p. 207

PLATE XXI

PLATE XXII

(All figures magnified X 1,000 unless otherwise mentioned)

1, 2 Aquilapollenites granulatus Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961, in different foci p. 207

3, 4 Aquilapollenites granulatus Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961, in different foci p. 207

5, 6 Aquilapollenites insignis Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961, in different foci p. 208

PLATE XXII

PLATE XXIII

(All figures magnified X 1,000 unless otherwise mentioned)

1-4 Aquilapollenites polaris Funkhouser 1961, figs. 1, 2 same pollen in different foci p. 209

5, 6 Aquilapollenites spinulosus Funkhouser 1961, in different foci p. 210

7-12 Aquilapollenites decorus n. sp.; figs. 7, 8 Holotype in different foci; fig. 9 Isotype; fig. 10 Isotype; fig. 11 Isotype; fig. 12 Isotype p. 210

PLATE XXIII

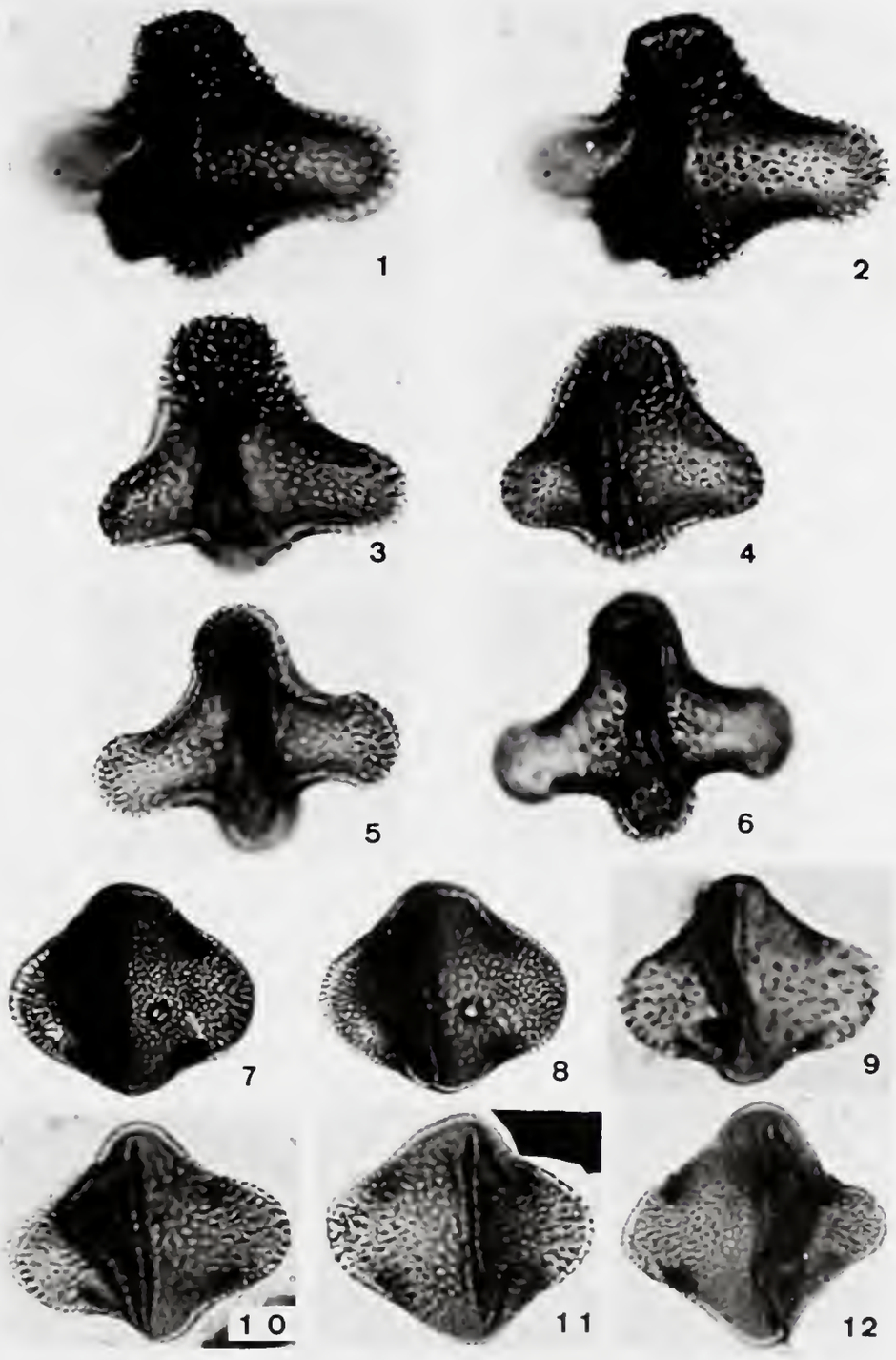

PLATE XXIV

(All figures magnified X 1,000 unless otherwise mentioned)

1, 2 *Aquilapollenites amicus* n. sp. (Holotype), fig. 1 showing retipilate ornamentation on pollen-body, fig. 2 showing pilate structure of sexine p. 211

3-5 *Aquilapollenites amygdaloides* n. sp. (Holotype), fig. 3 X 500, showing general features of pollen, fig. 4 showing retipilate ornamentation on pollen-body, fig. 5 showing meridional colpi and retipilate ornamentation on equatorial projection p. 212

6 *Aquilapollenites antigonei* n. sp. (Holotype), showing retipilate ornamentation on pollen-body and pilate structure of sexine p. 213

7-9 *Aquilapollenites catenireticulatus* n. sp. (Holotype), fig. 7 showing reticulate ornamentation of body and the bastionate nature of sexine, fig. 8 X 500 showing general features of pollen, fig. 9 showing chain-like arrangement of reticulations p. 214

PLATE XXIV

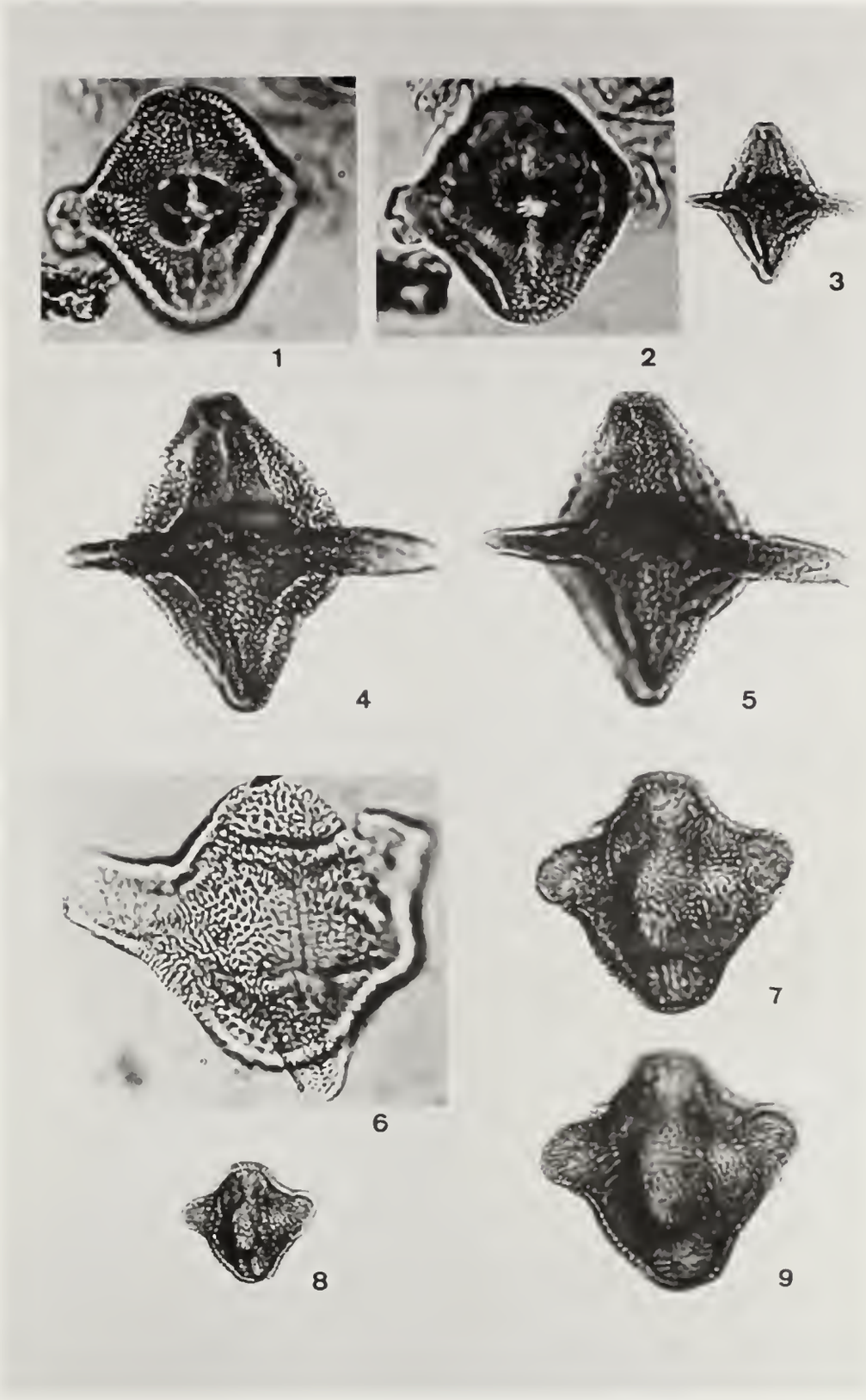

PLATE XXV

(All figures magnified X 1,000 unless otherwise mentioned)

1-4 Aquilapollenites ceriocorpus n. sp. (Holotype), fig. 1 showing reticulate ornamentation at the margin of one polar projection and the bastionate nature of sexine, fig. 2 showing reticulations at the equatorial region of pollen-body, fig. 3 showing sexine structure and the ornamentation of other polar projection, fig. 4 showing details of ornamentation on equatorial projection p. 215

5-7 Aquilapollenites debilis n. sp. (Holotype), fig. 5 X 500, showing general features of pollen, fig. 6 showing retipilate ornamentation of pollen-body, fig. 7 showing details of thick band of sexine on equatorial projection p. 216

PLATE XXV

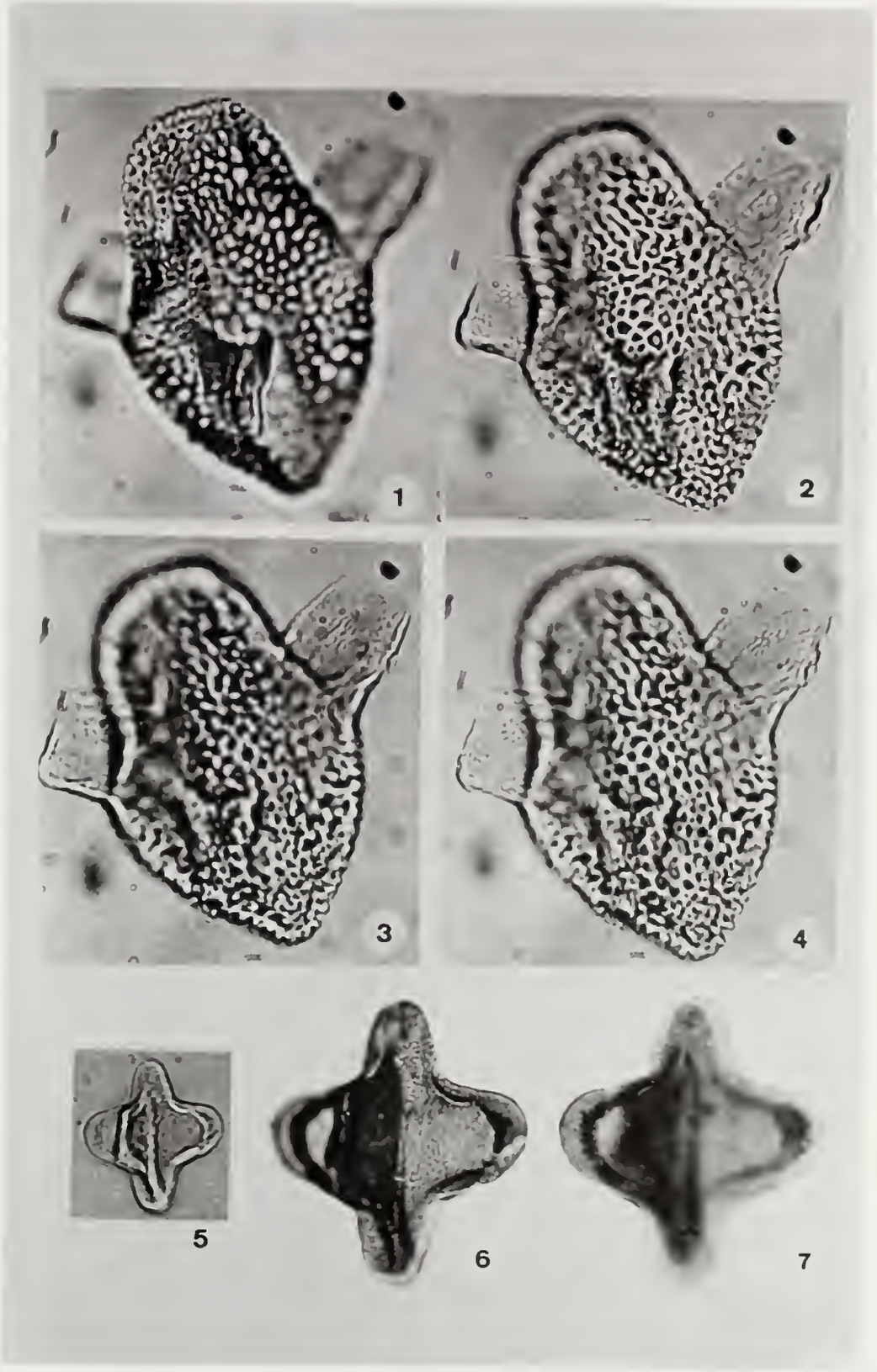

PLATE XXVI

(All figures magnified X 1,000 unless otherwise mentioned)

1-5 Aquilapollenites leucocephalus n. sp. (Holotype), fig. 1 X 500, showing general features of pollen, fig. 2 showing reticulate ornamentation on one polar projection, fig. 3 showing fine reticulate ornamentation on central portion of equatorial region of body, fig. 4 showing reticulate ornamentation of other polar projection, fig. 5 showing fine reticulate ornamentation in equatorial region between two equatorial projections p. 217

6 Aquilapollenites medeis n. sp. (Holotype), showing bastionate nature of sexine p. 219

PLATE XXVI

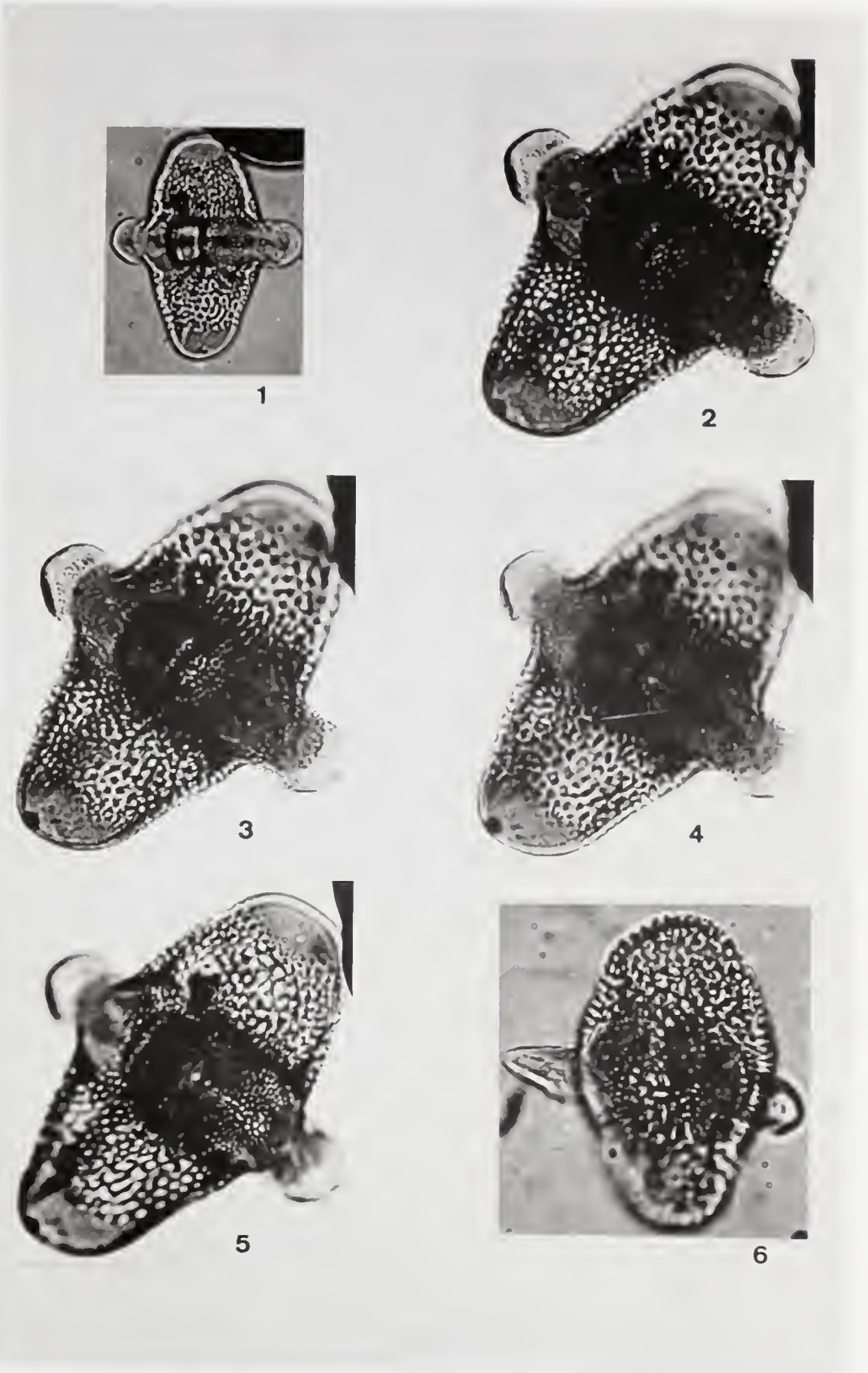

PLATE XXVII

(All figures magnified X 1,000 unless otherwise mentioned)

1, 2 Aquilapollenites medeis n. sp. (Holotype), fig. 1 X 500 showing general features of pollen, fig. 2 showing reticulate ornamentation of pollen-body p. 219

3-5 Aquilapollenites mirabilis n. sp. (Isotype), fig. 3 X 500, showing general features of pollen; fig. 4 showing bastionate nature of sexine at margin of one polar projection, fig. 5 showing reticulate ornamentation of pollen-body and equatorial projection p. 220

6-8 Aquilapollenites mirabilis n. sp. (Holotype), fig. 6 X 500 showing general features of pollen, fig. 7 showing bastionate nature of sexine on the margin of body, fig. 8 showing reticulate ornamentation of pollen-body and details of equatorial projection p. 220

PLATE XXVII

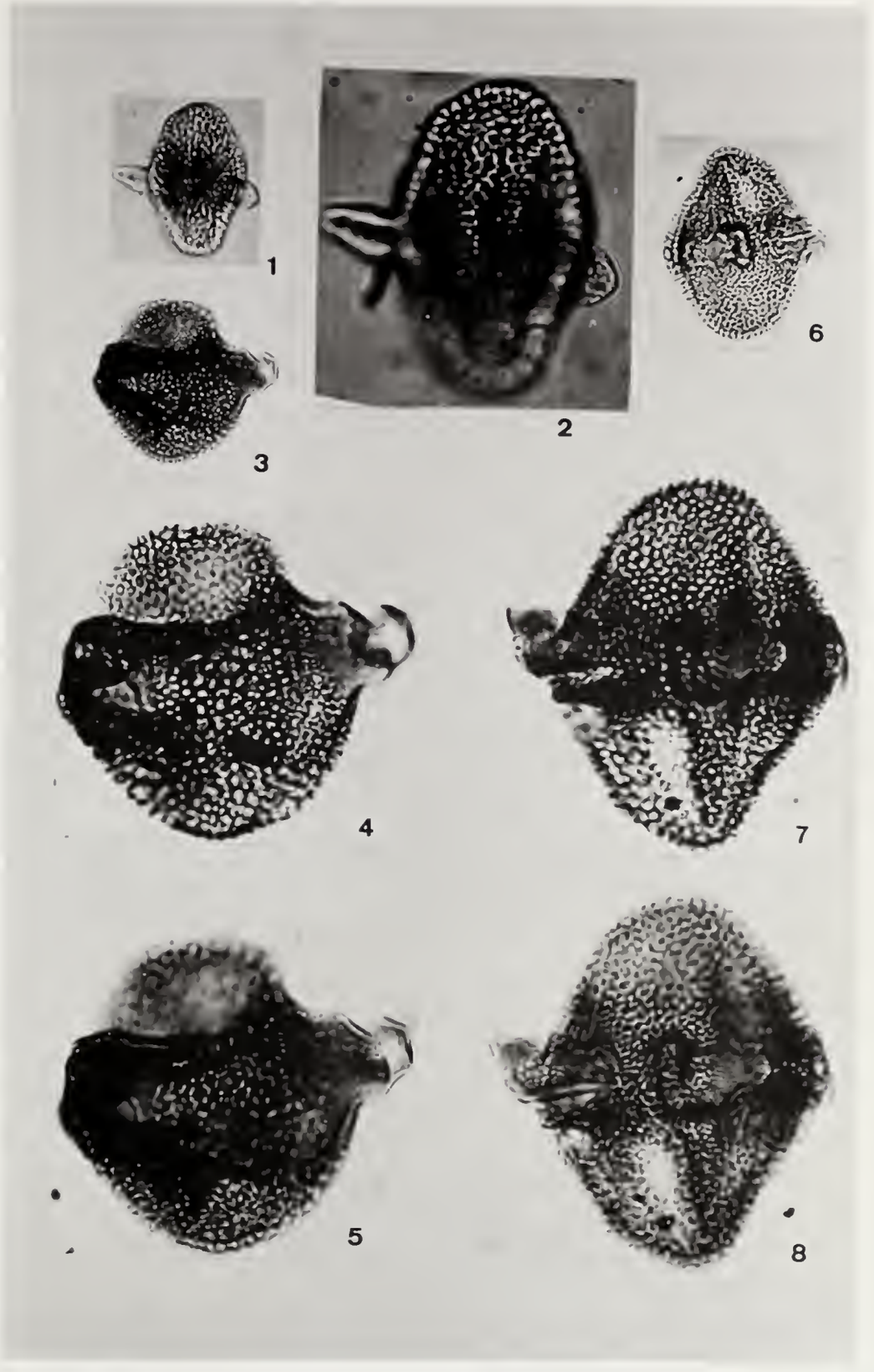

PLATE XXVIII

(All figures magnified X 1,000 unless otherwise mentioned)

1, 2 Aquilapollenites oblatus n. sp., fig. 1 showing details of ornamentation on margin of pollen-body, fig. 2 showing details of ornamentation on central part of pollen-body p. 221

3-5 Aquilapollenites oblatus n. sp. (Holotype), fig. 3 X 500, showing general features of pollen, fig. 4 showing reticulate ornamentation of sexine on one polar projection, fig. 5 showing reticulate ornamentation on other polar projection p. 221

6 Aquilapollenites oblatus n. sp., showing meridional colpi and detailed reticulate ornamentation on pollen-body and equatorial projections p. 221

7-9 Aquilapollenites stelckii n. sp. (Holotype), fig. 7 X 500 showing general features of pollen, fig. 8 showing details of retipilate sexine structure of one polar projection, fig. 9 showing sexine ornamentation and structure of other polar projection, central body and equatorial projection p. 222

10, 11 Aquilapollenites validus n. sp. (Holotype), fig. 10 X 500 showing general features of pollen, fig. 11 showing retipilate ornamentation of sexine p. 224

PLATE XXVIII

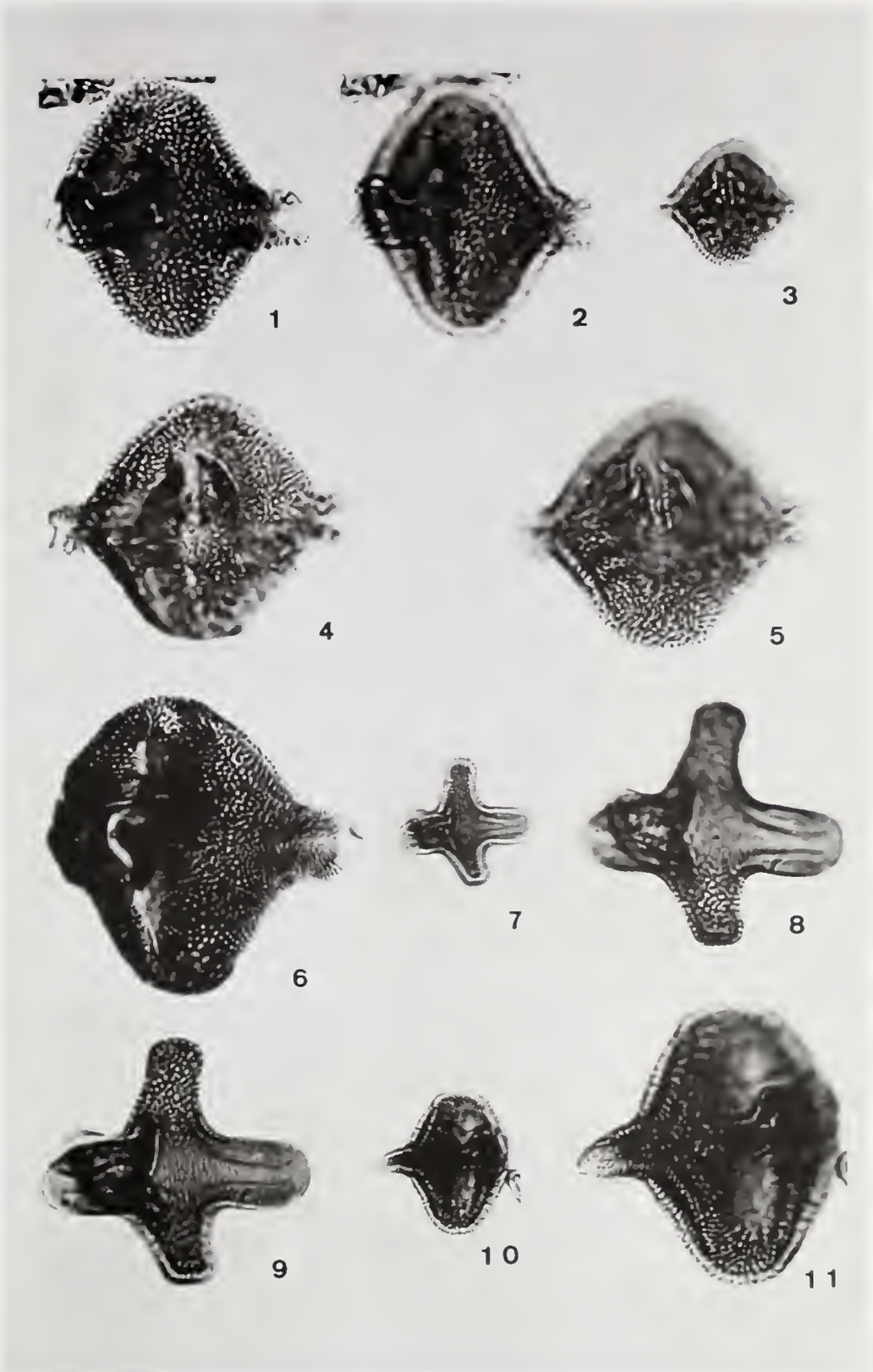

PLATE XXIX

(All figures magnified X 1,000 unless otherwise mentioned)

1 — Aquilapollenites validus n. sp. (Holotype), showing retipilate ornamentation of sexine and meridional and equatorial colpi p. 224

2-4 — Aquilapollenites venustus n. sp. (Holotype), fig. 2 X 500 showing general features of pollen, fig. 3 showing retipilate ornamentation on one polar projection, fig. 4 showing ornamentation on other polar projection in focus p. 225

5, 6 — Aquilapollenites venustus n. sp., fig. 5 X 500 showing general features of pollen, fig. 6 showing details of ornamentation on pollen-body p. 225

7-9 — Aquilapollenites dolium (Samoilovitch) n. comb., fig. 7 showing details of retipilate ornamentation of pollen-body, fig. 8 X 500 showing general features of pollen, fig. 9 showing details of sexine structure on the margin of pollen-body p. 226

10, 11 — Aquilapollenites funkhouseri Srivastava 1966, fig. 10 X 500 showing general features of pollen, fig. 11 showing reticulate ornamentation on pollen-body p. 227

PLATE XXIX

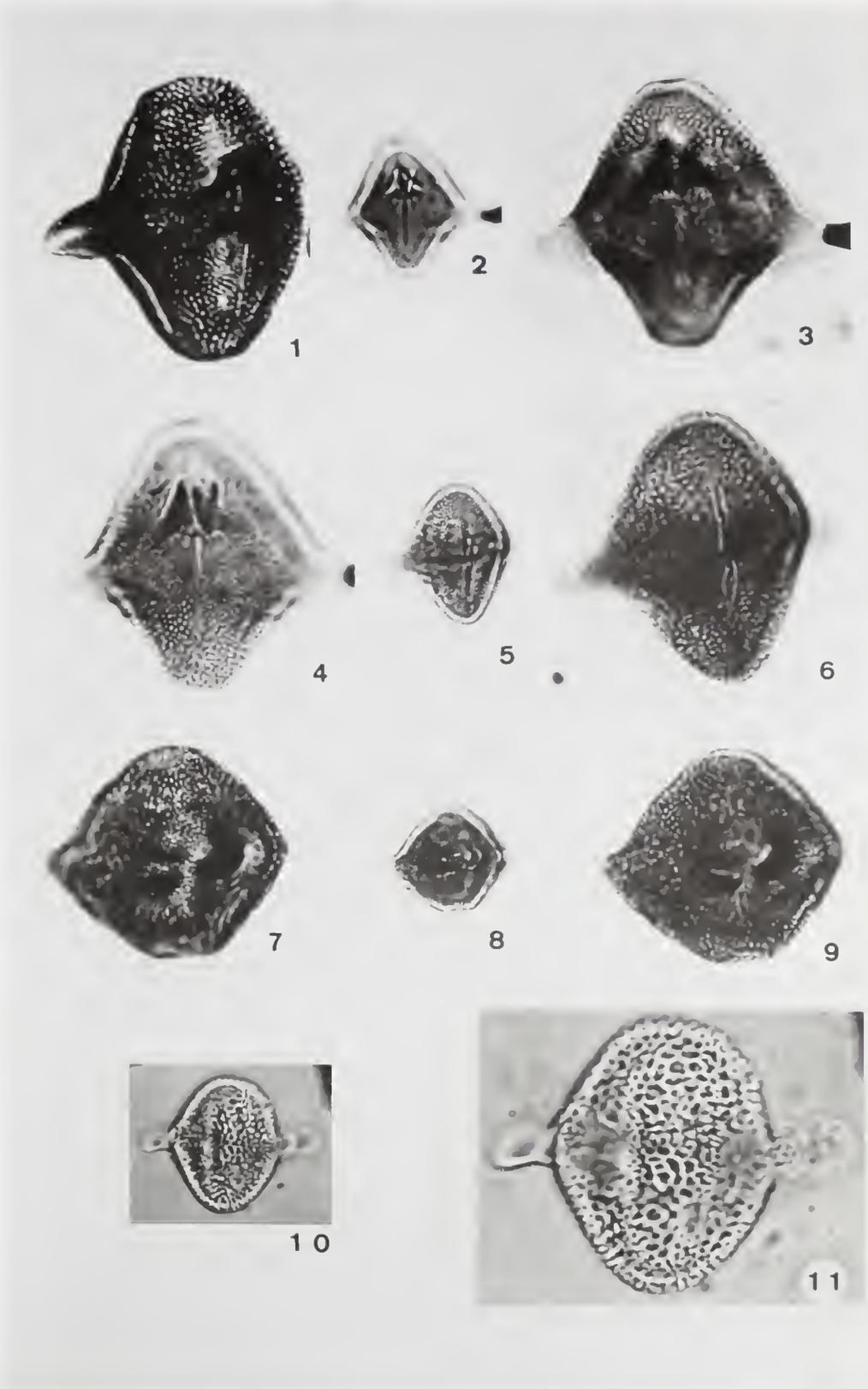

PLATE XXX

(All figures magnified X 1,000 unless otherwise mentioned)

1-3 Aquilapollenites funkhouseri Srivastava 1966, figs. 1 and 2 showing reticulate ornamentation on pollen-body and equatorial projections, fig. 3 X 500 showing general features of pollen p. 227

4-7 Aquilapollenites reductus Norton 1965, fig. 4 X 500 showing general features of pollen, figs. 5-7 showing details of reticulate ornamentation of different areas of pollen-body in focus p. 228

PLATE XXX

PLATE XXXI

(All figures magnified X 1,000 unless otherwise mentioned)

1-4	Aquilapollenites vinosus n. sp. (Holotype), fig. 1 X 500, figs. 3-5 serial microphotographs showing different parts of holotype in focus	p. 229
5, 6	Aquilapollenites alveolatus Jardine and Magloire 1965, in different foci	p. 230
7	Aquilapollenites minutus Srivastava 1966	p. 231

PLATE XXXI

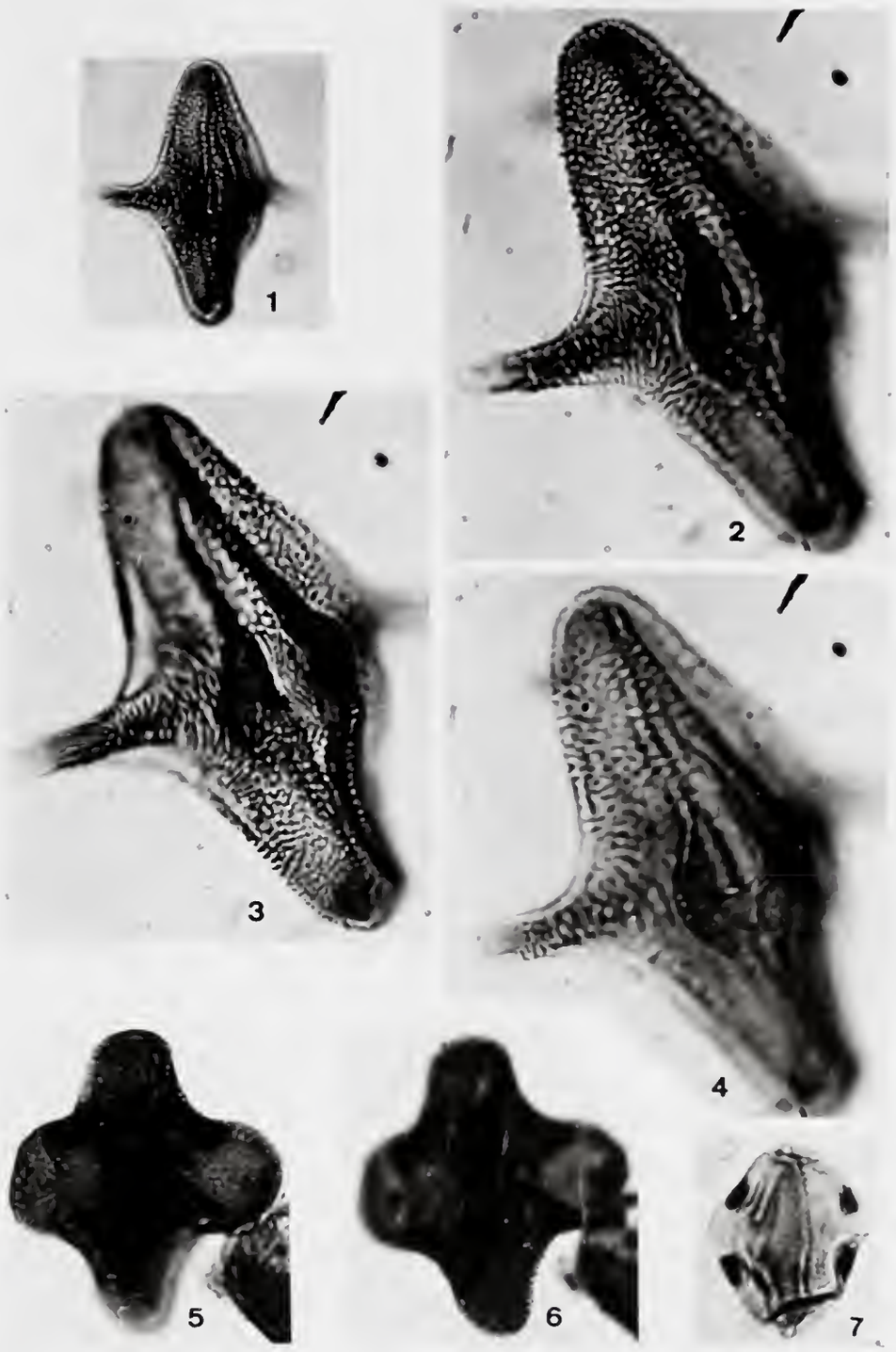

PLATE XXXII

(All figures magnified X 1,000 unless otherwise mentioned)

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3, 4	Aquilapollenites conatus Norton 1965, slightly tilted polar view in different foci	p. 231
5	Aquilapollenites macgregorii Srivastava 1966	p. 232
6, 7	Loranthacites catterallii n. sp., fig. 6 Holotype; fig. 7 Isotype	p. 108

PLATE XXXII

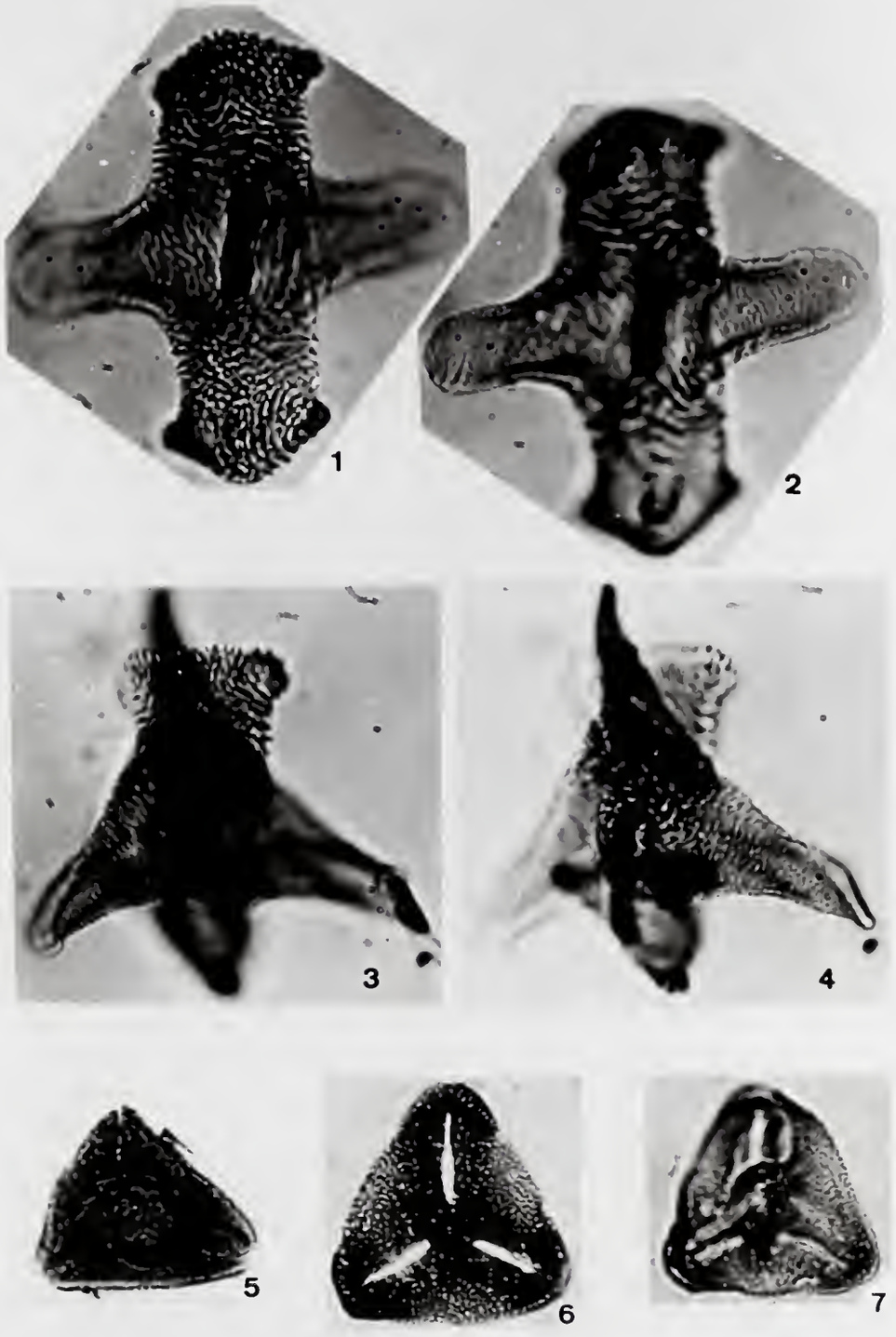

PLATE XXXIII

(All figures magnified X 1,000 unless otherwise mentioned)

1, 2	Mancicorpus albertensis n. sp.; fig. 1 Holotype; fig. 2 Isotype	p. 235
3-5	Mancicorpus gibbus n. sp. (Holotype), fig. 3 X 500 figs. 4, 5 details of holotype in different foci	p. 236
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9, 10	Mancicorpus senonicus Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961, in different foci	p. 238

PLATE XXXIII

PLATE XXXIV

(All figures magnified X 1,000 unless otherwise mentioned)

1, 2 — Mancicorpus rostratus n. sp. (Holotype), fig. 1 X 500, fig. 2 details of holotype — p. 239

3, 4 — Mancicorpus vancampoi n. sp. (Holotype), fig. 3 X 500, fig. 4 details of holotype — p. 241

5, 6 — Mancicorpus anchoriforme Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961, in different foci — p. 242

7, 8 — Mancicorpus solidus Mtchedlishvili in Samoilovitch and Mtchedlishvili 1961, fig. 7 X 500, fig. 8 details of the same — p. 243

PLATE XXXIV

PLATE XXXV

(All figures magnified X 1,000 unless otherwise mentioned)

1-8 Mtchedlishvilia canadiana n. sp.; fig. 1 X 500 Holotype, fig. 2 details of holotype; fig. 3 X 500 Isotype, fig. 4 details of the same; figs. 5, 6 Isotype; figs. 7, 8 Isotype p. 245

PLATE XXXV

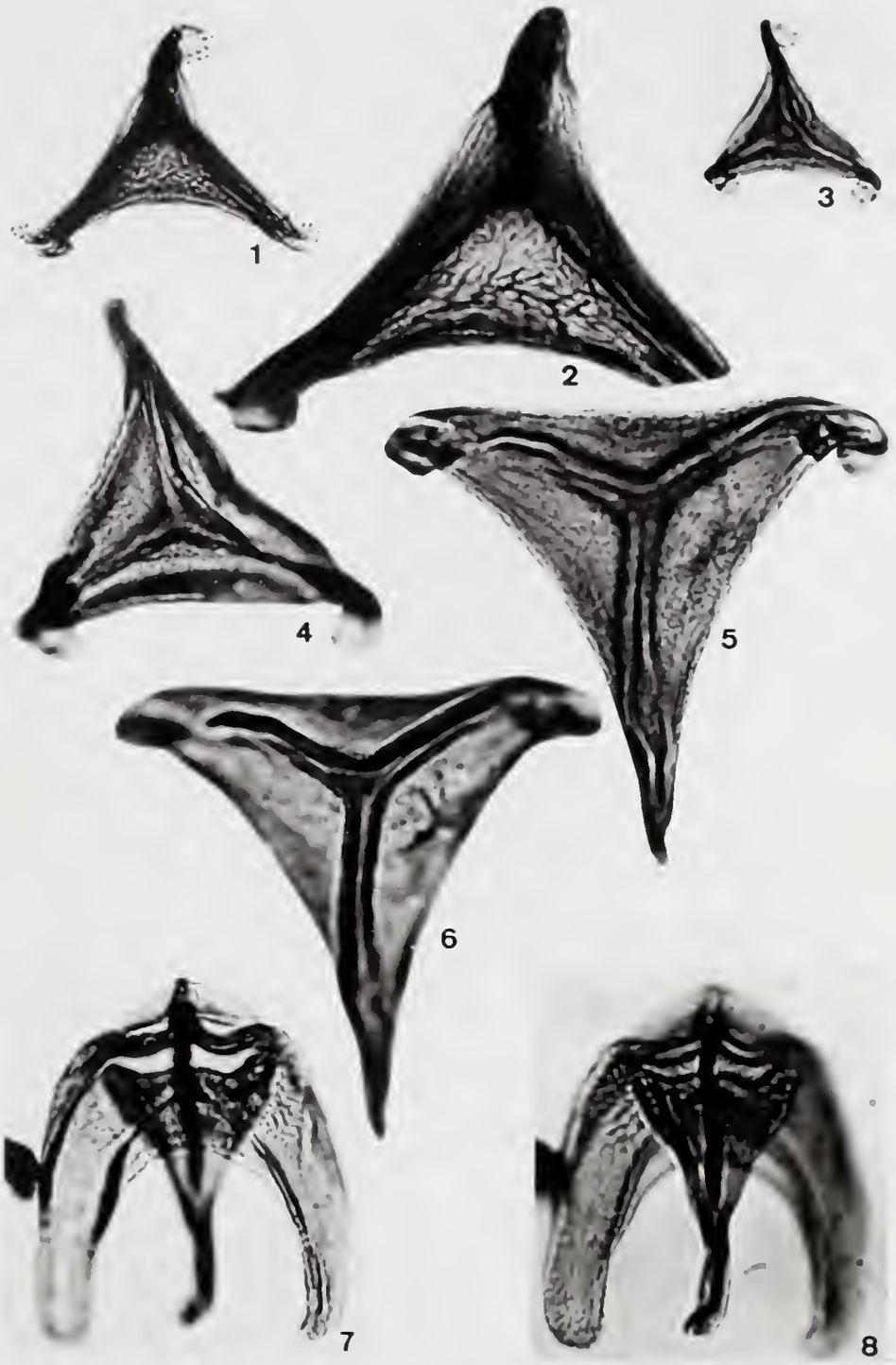

PLATE XXXVI

(All figures magnified X 1,000 unless otherwise mentioned)

1-3 *Wodehousea spinata* Stanley 1961; fig. 3 showing peeling of flange from the body p. 247

4, 5 *Wodehousea gracile* (Samoilovitch in Samoilovitch and Mtchedlishvili) Samoilovitch 1967 p. 248

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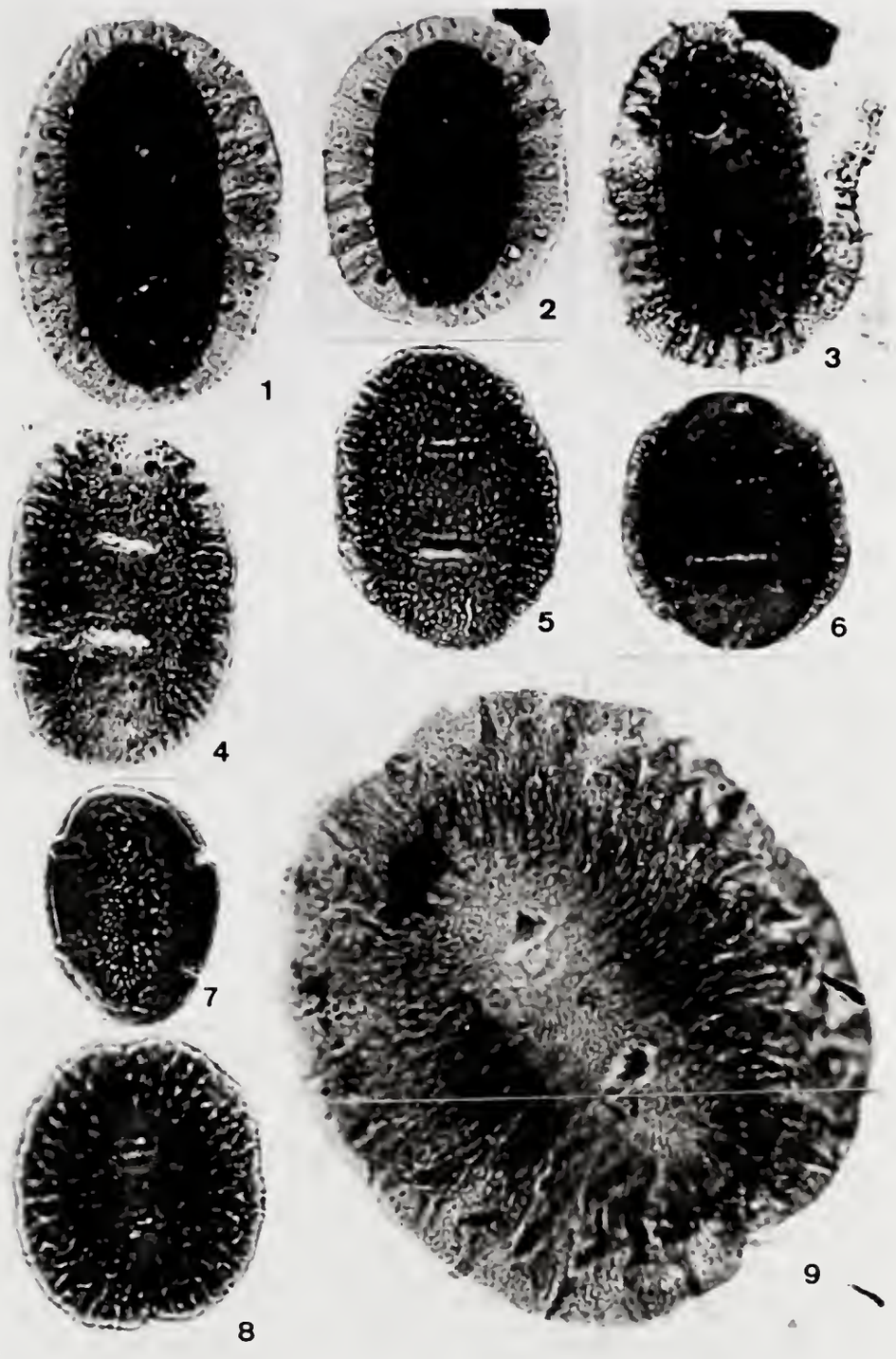
8, 9 *Wodehousea fimbriata* Stanley 1961, fig. 8 X 500, fig. 9 details of the same p. 249

PLATE XXXVI



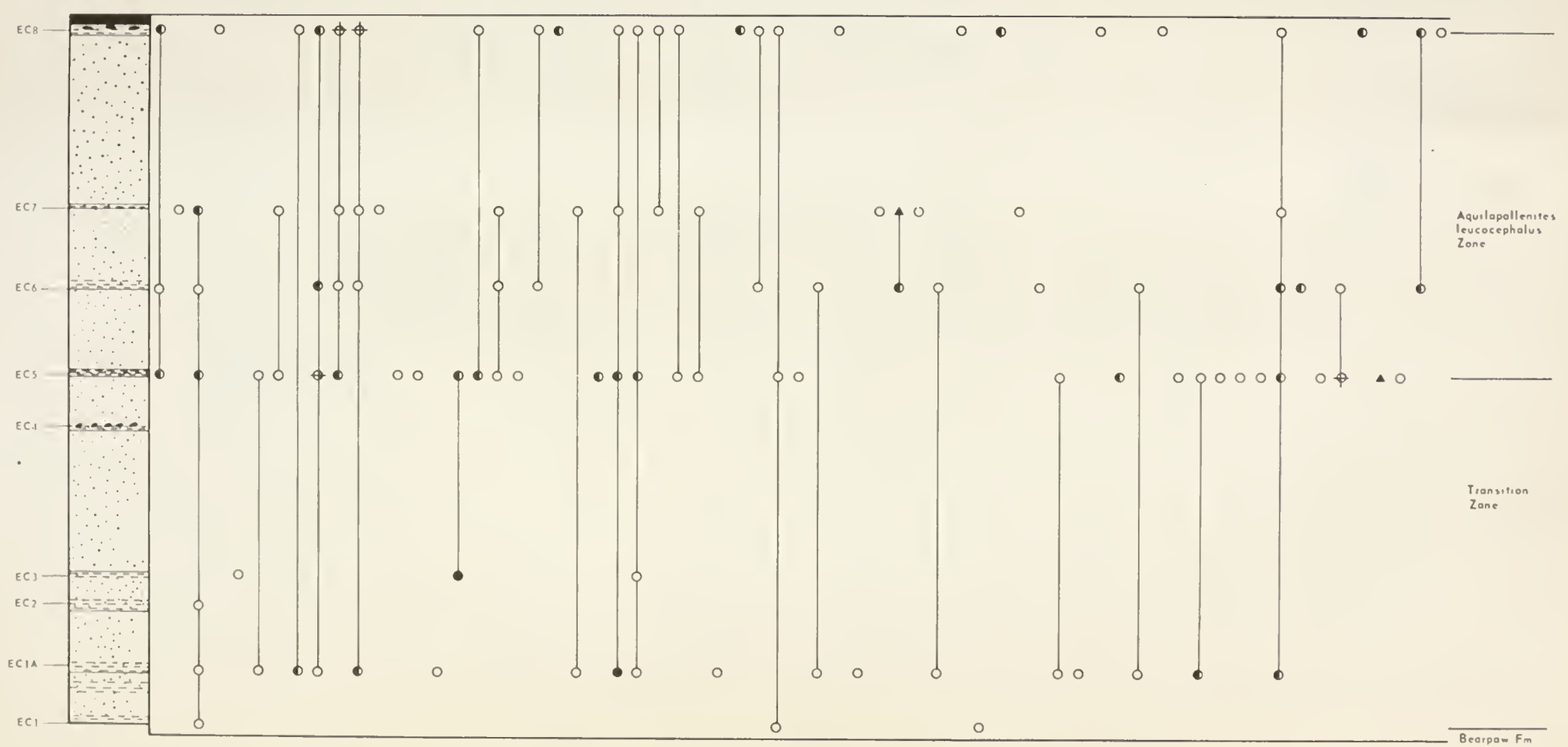


Fig. 9 Distribution of angiosperm species in the East Coulee section, Alberta

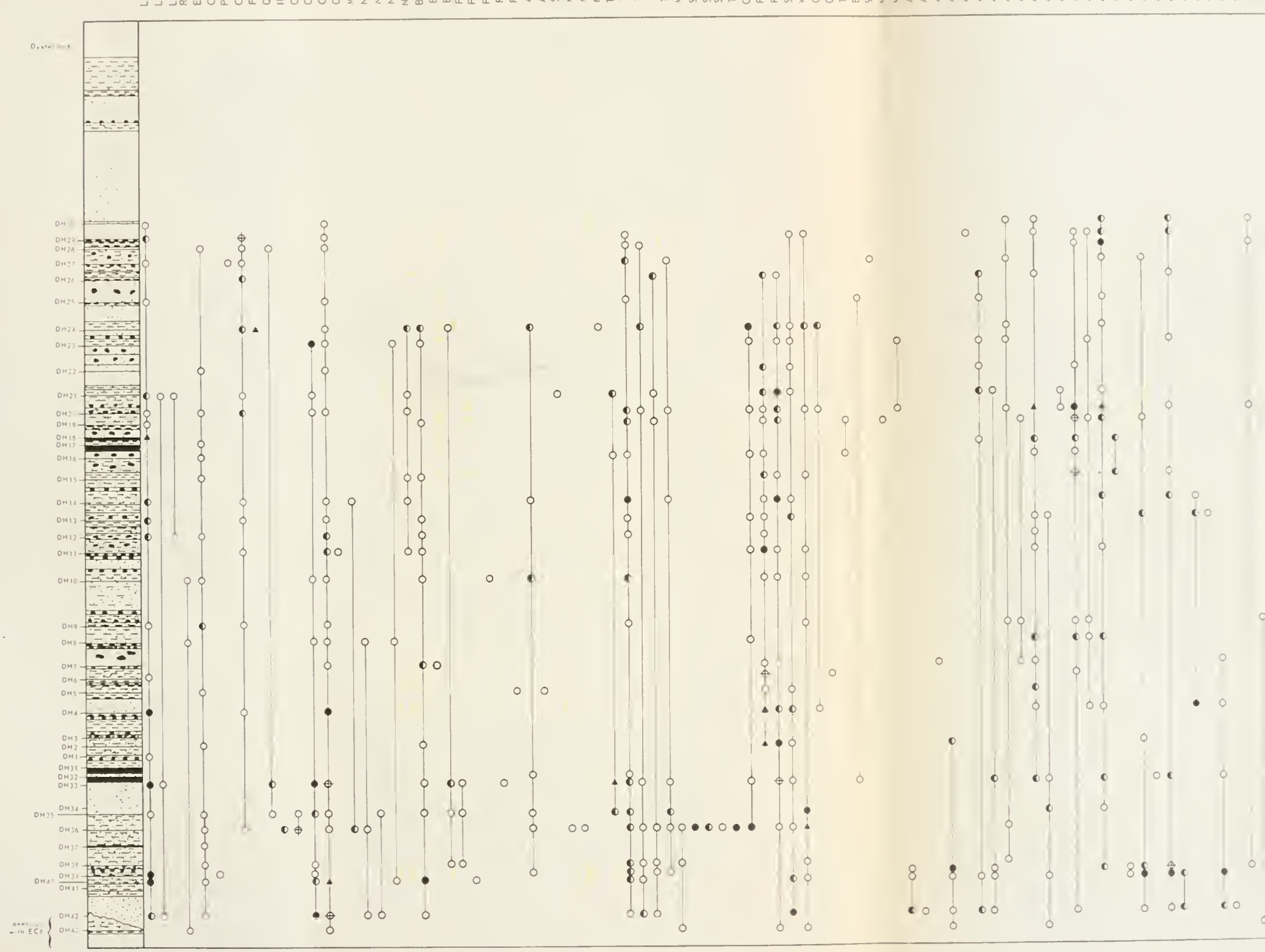


Fig. 10 Distribution of angiosperm species in the Drumheller section, Alberta

A. hirsutus
A. hispidus
A. papillatus
A. petasus
A. pudicus
A. pumilis
A. regalis
A. sentus
A. stellatus
A. amplus
A. asper
A. granulatus
A. insignis
A. polaris
A. spinulosus
A. decorus
A. alvealatus
A. macgregorii
A. minutus
Mancicorpus albertensis
M. borealis
M. rostratus
M. senonicus
M. solidus
Mtchedlishvilia canadiana
Wodehouseia gracile
W. iacutense
Laranthacites catterallii
Pulcheripollenites krempii Zone
Mancicorpus borealis Subzone
Wodehouseia iacutense and W. gracile Zone
Vertical Scale 20 ft
Legend
Rare
Common
Rich
Abundant
Flooding

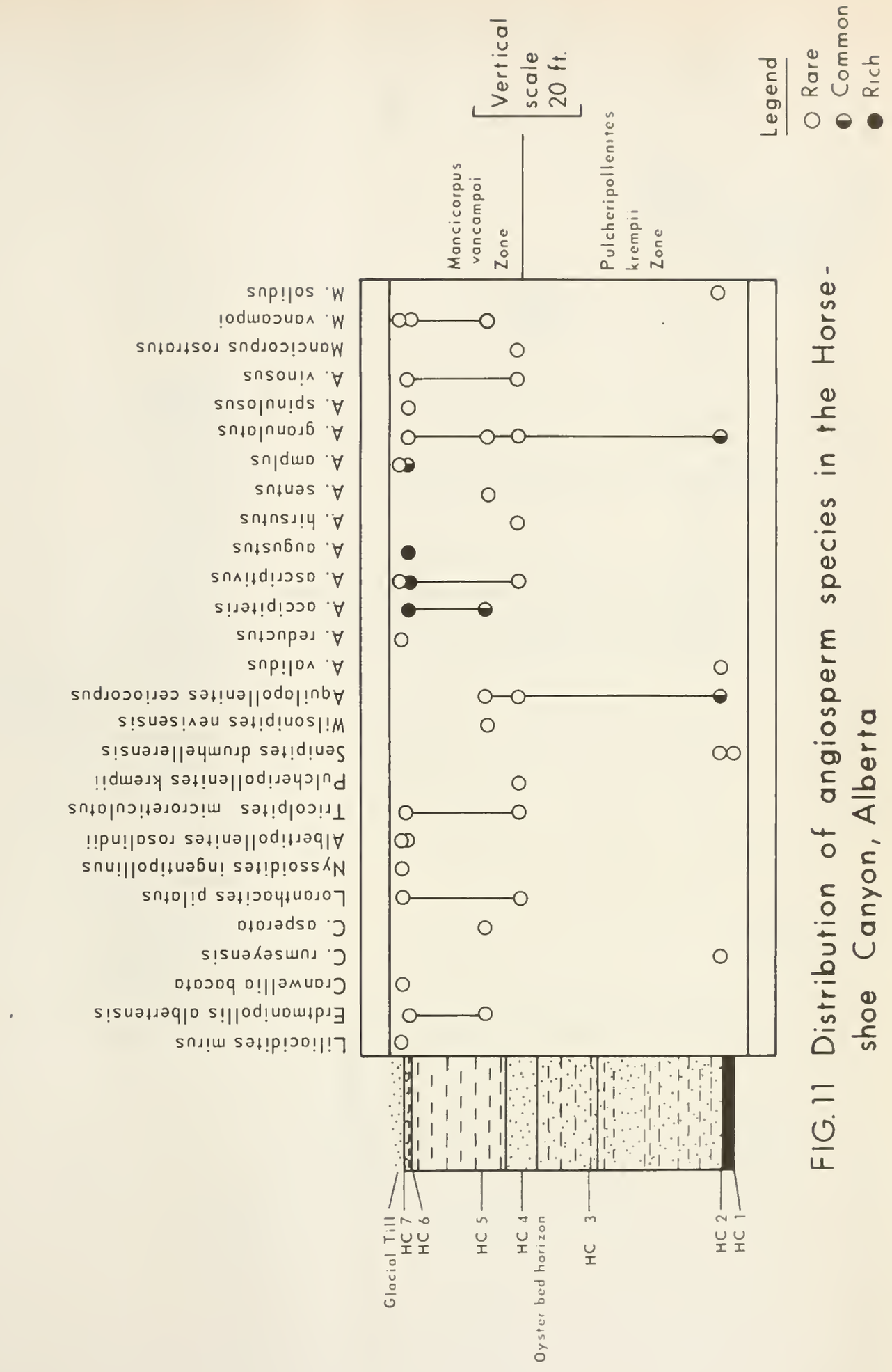


FIG. 11 Distribution of angiosperm species in the Horseshoe Canyon, Alberta

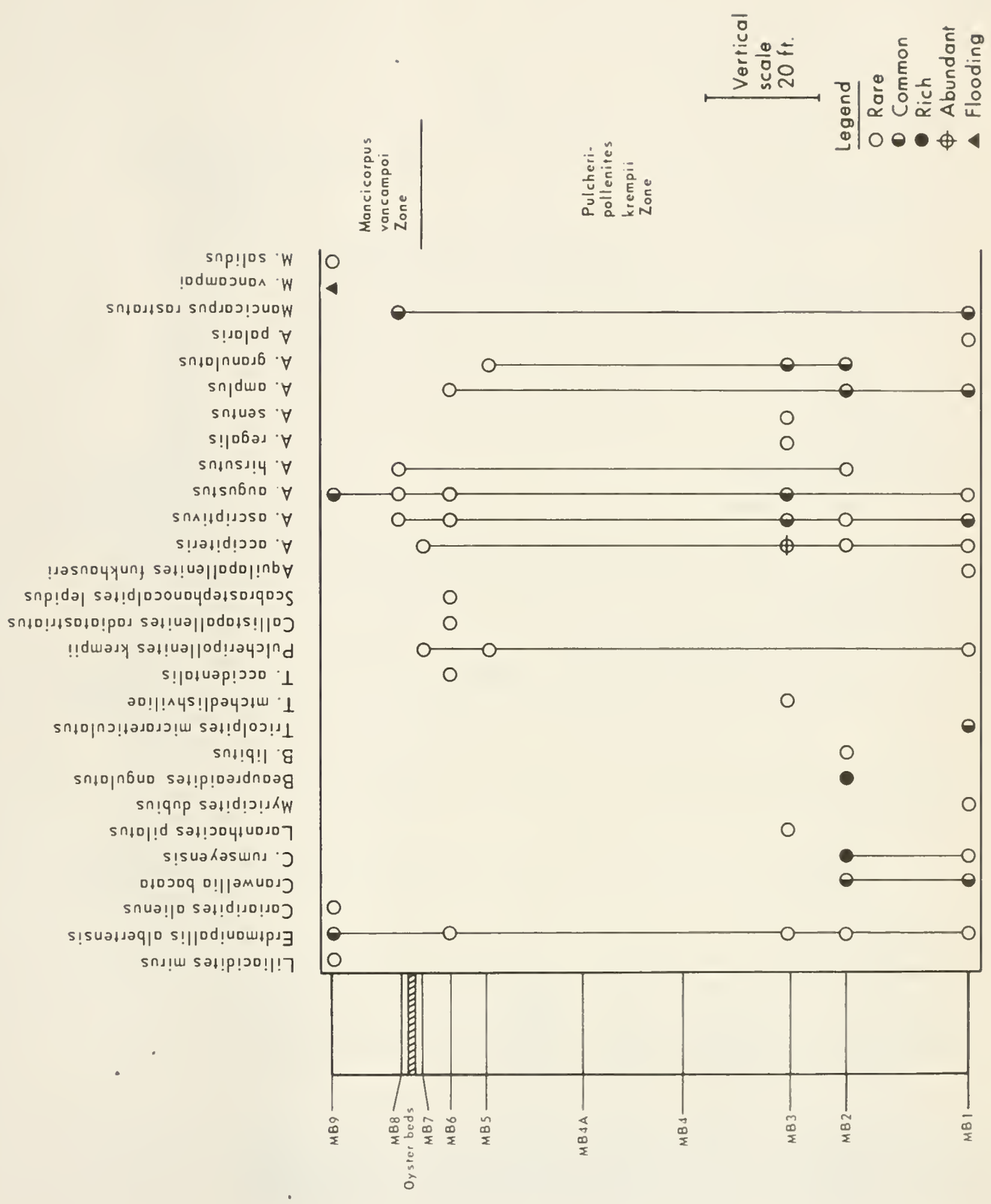


Fig. 12 Distribution of angiosperm species in the Morrin Bridge section, Alberta

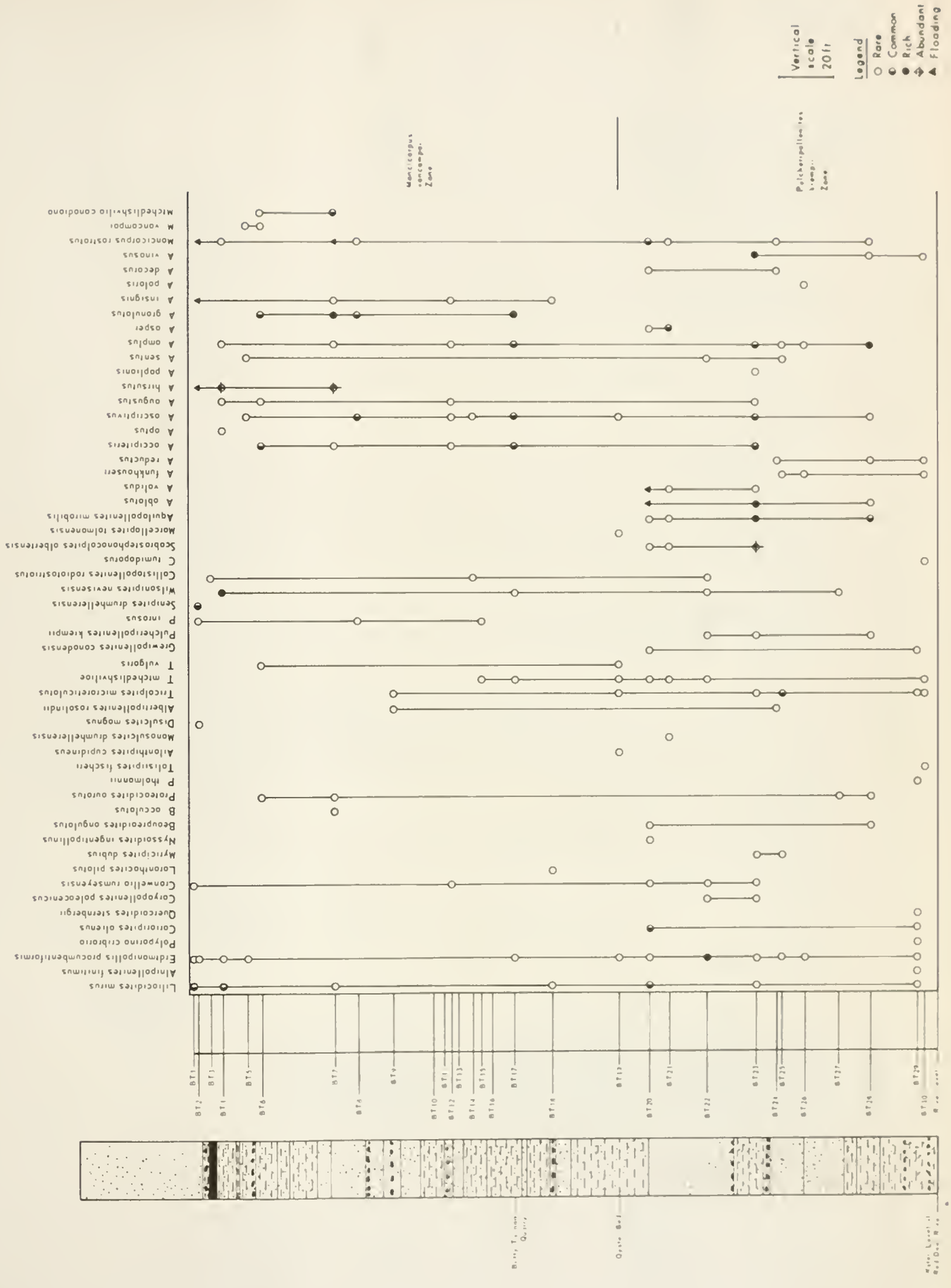


Fig. 13 Distribution of angiosperm species in the Betty Tolman section, Alberta

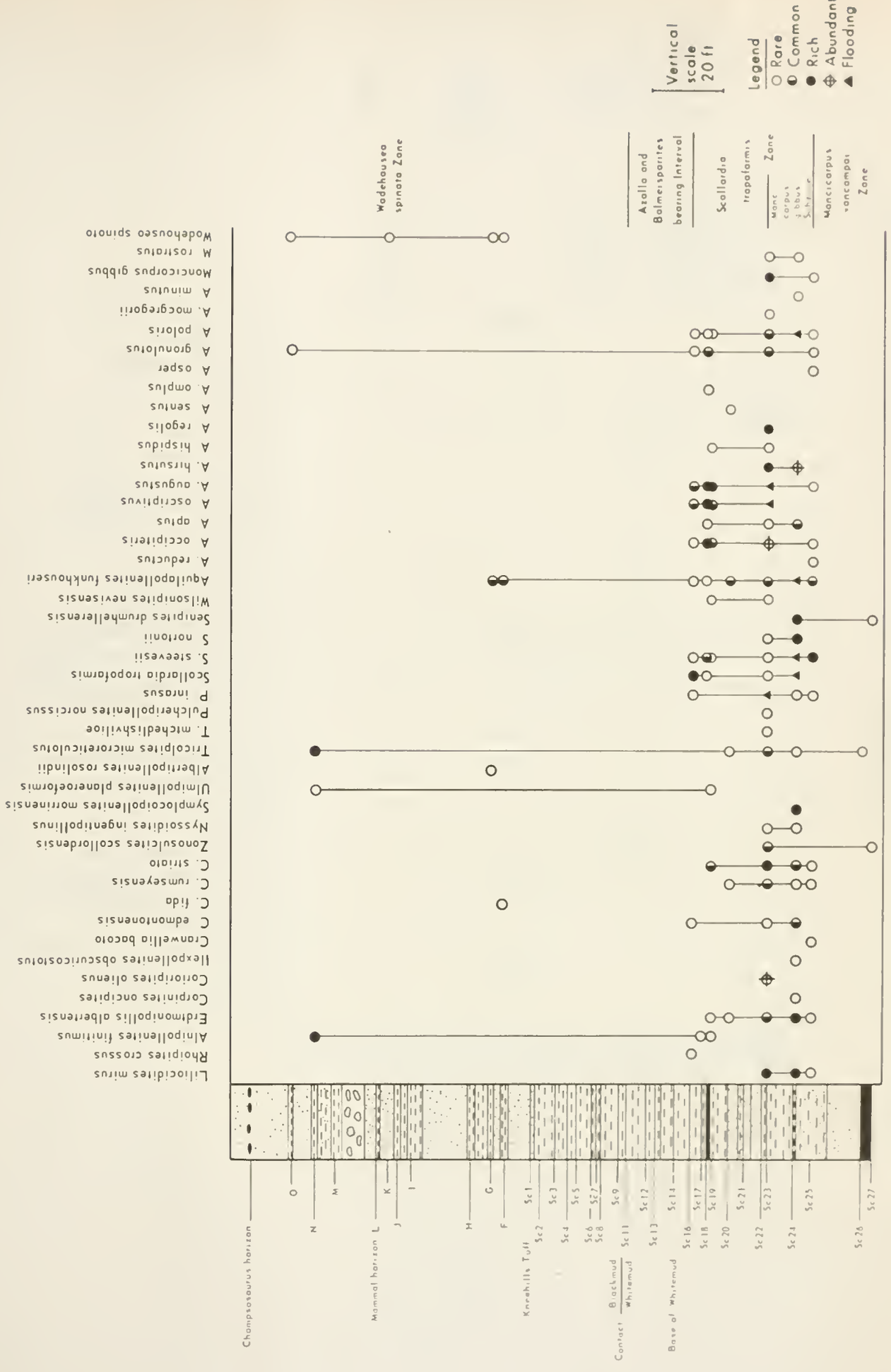


Fig. 14 Distribution of angiosperm species in Scollard Locality 1, Alberta

Fig.15 Distribution of angiosperm species in the Scollard Locality 18, Alberta

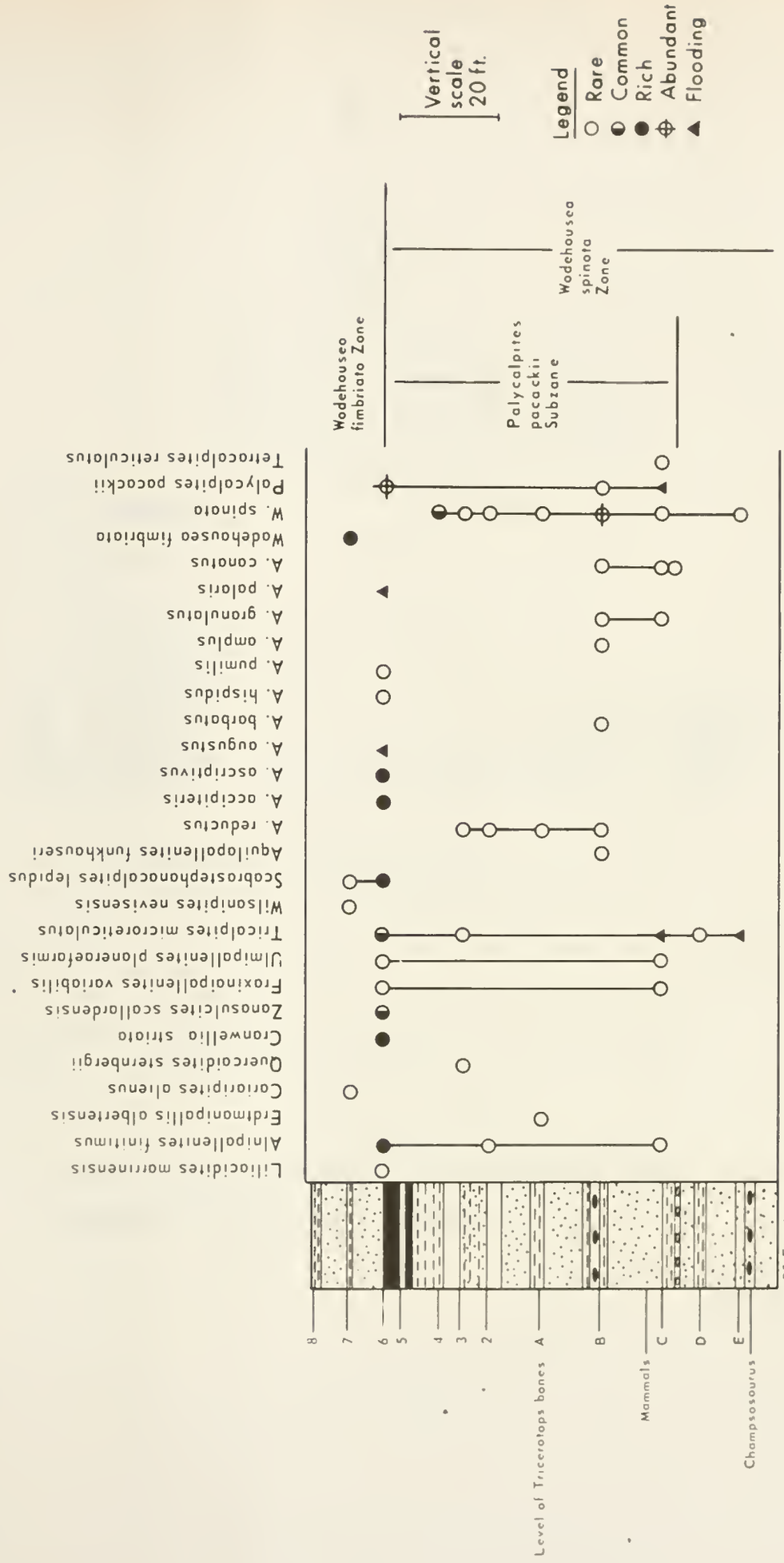


Fig. 16 Distribution of angiosperm species in the Scollard Locality 2, Alberta

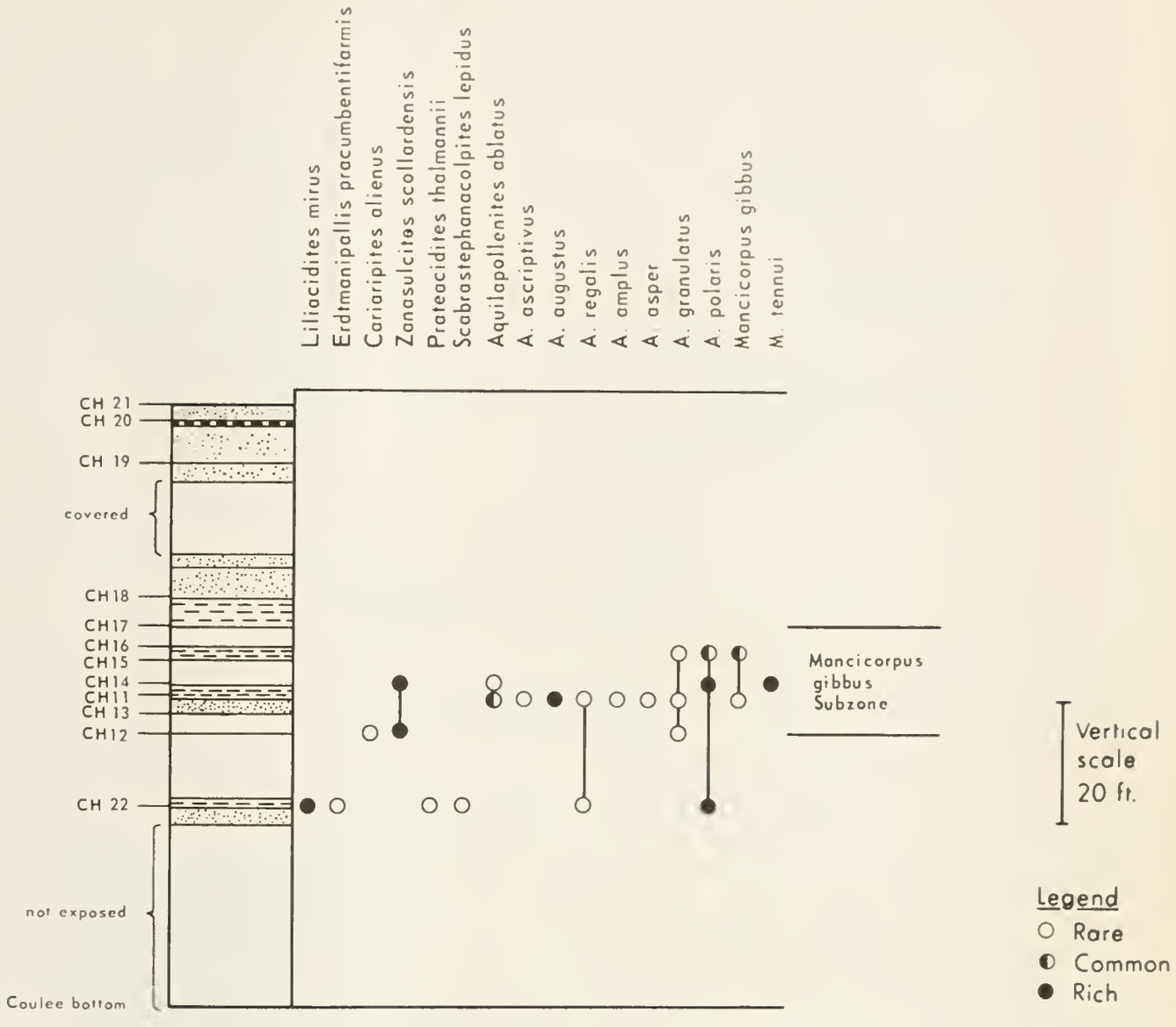


Fig. 17 Distribution of angiosperm species in the Cypress Hills section, Alberta

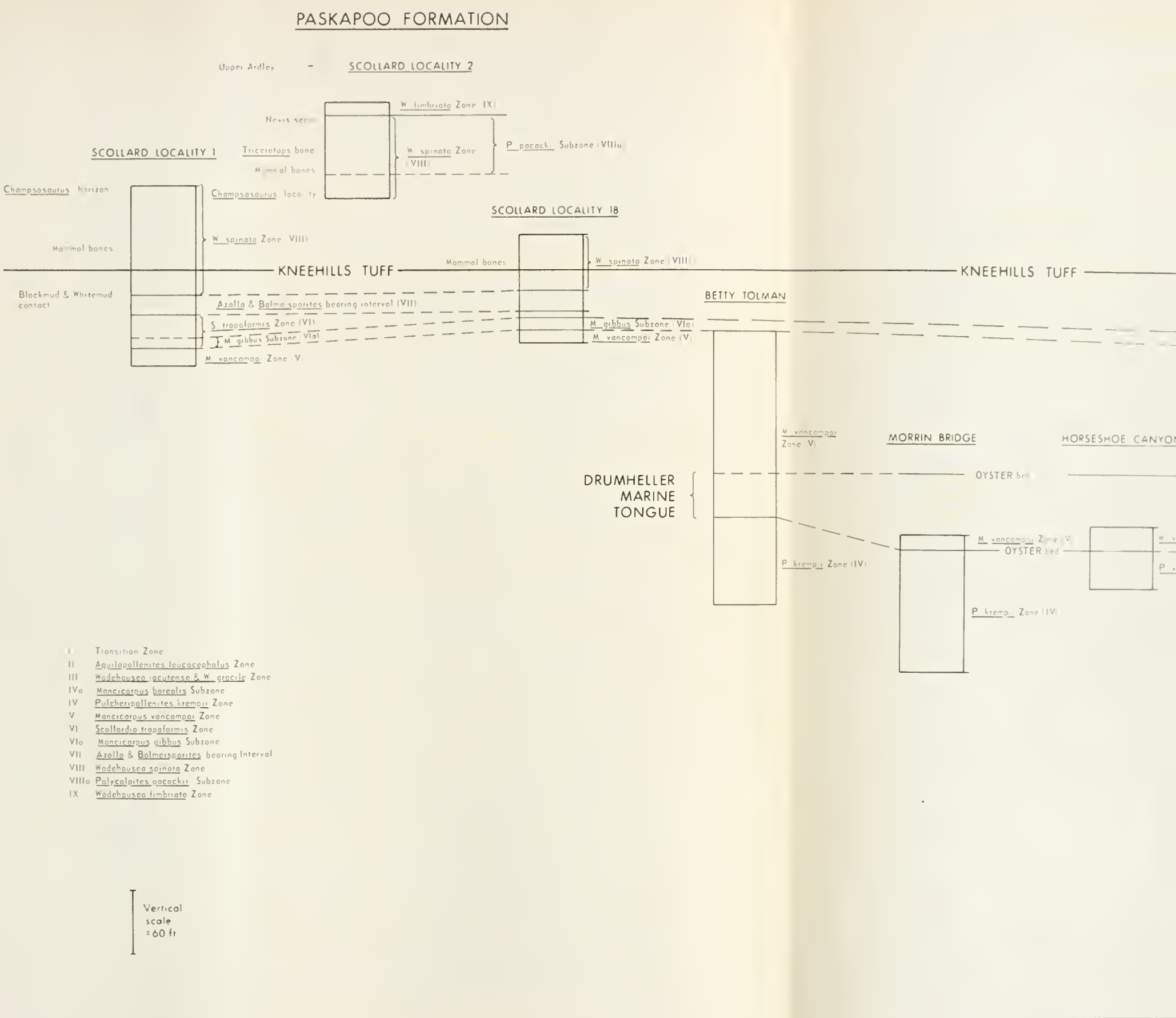
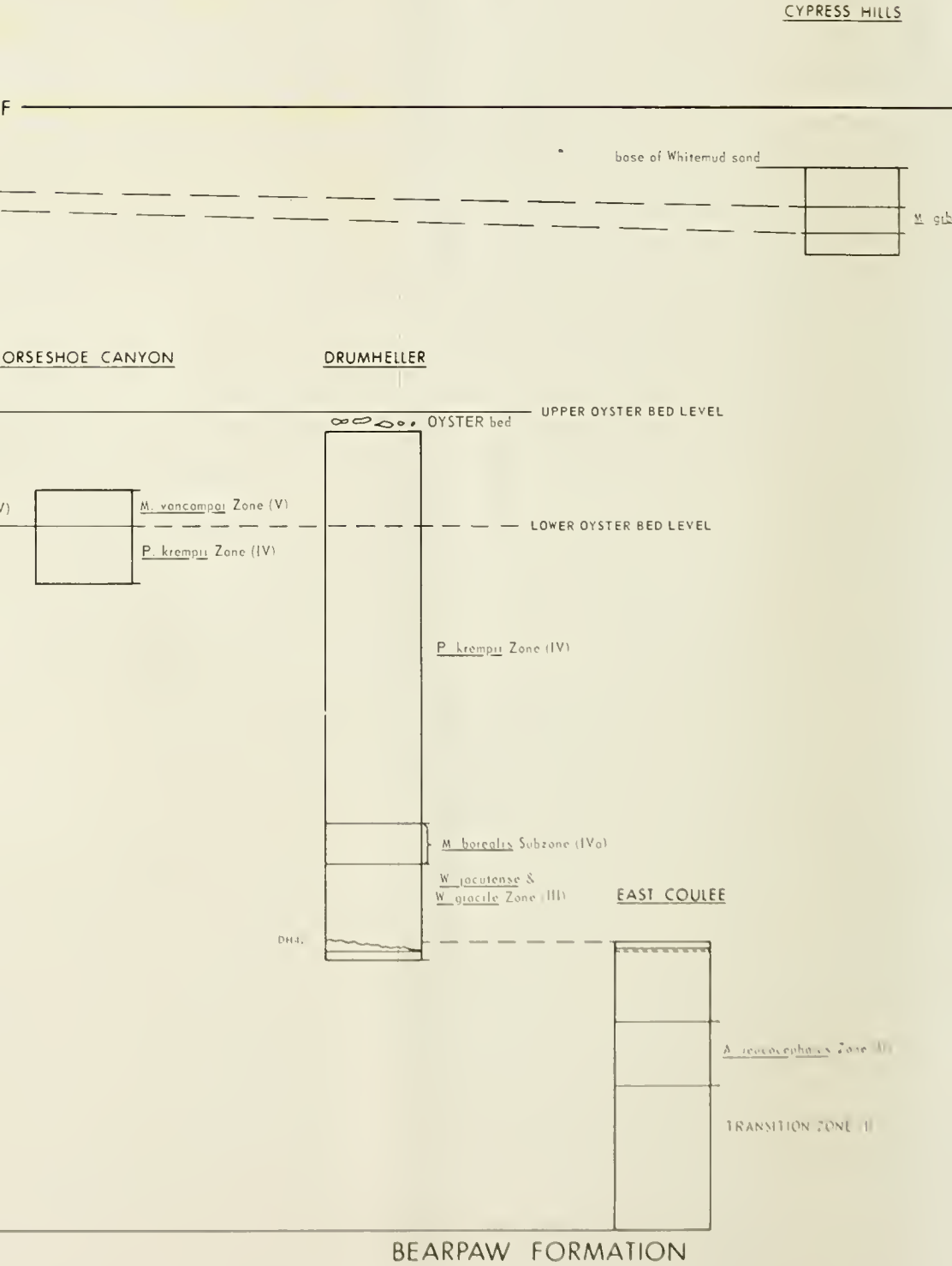


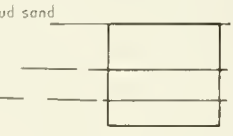
Fig. 18 Correlation of various sections of the Edmonton Formation studied.


CYPRESS HILLS
base of Whitemud sand
ORSESHOE CANYON
DRUMHELLER
UPPER OYSTER BED LEVEL
OYSTER bed
M. vancampoi Zone (V)
LOWER OYSTER BED LEVEL
P. krempii Zone (IV)
P. krempii Zone (IV)
M. borealis Subzone (IVa)
W. jacutense &
W. gracile Zone (III)
EAST COULEE
DH4.
TRANSITION ZONE
BEARPAW FORMATION

CYPRESS HILLS

KNEEHILLS TUFF

ud sand



M. gibbus Subzone(VIa)

L

E

A. leucocephalus Zone (II)

TRANSITION ZONE (I)

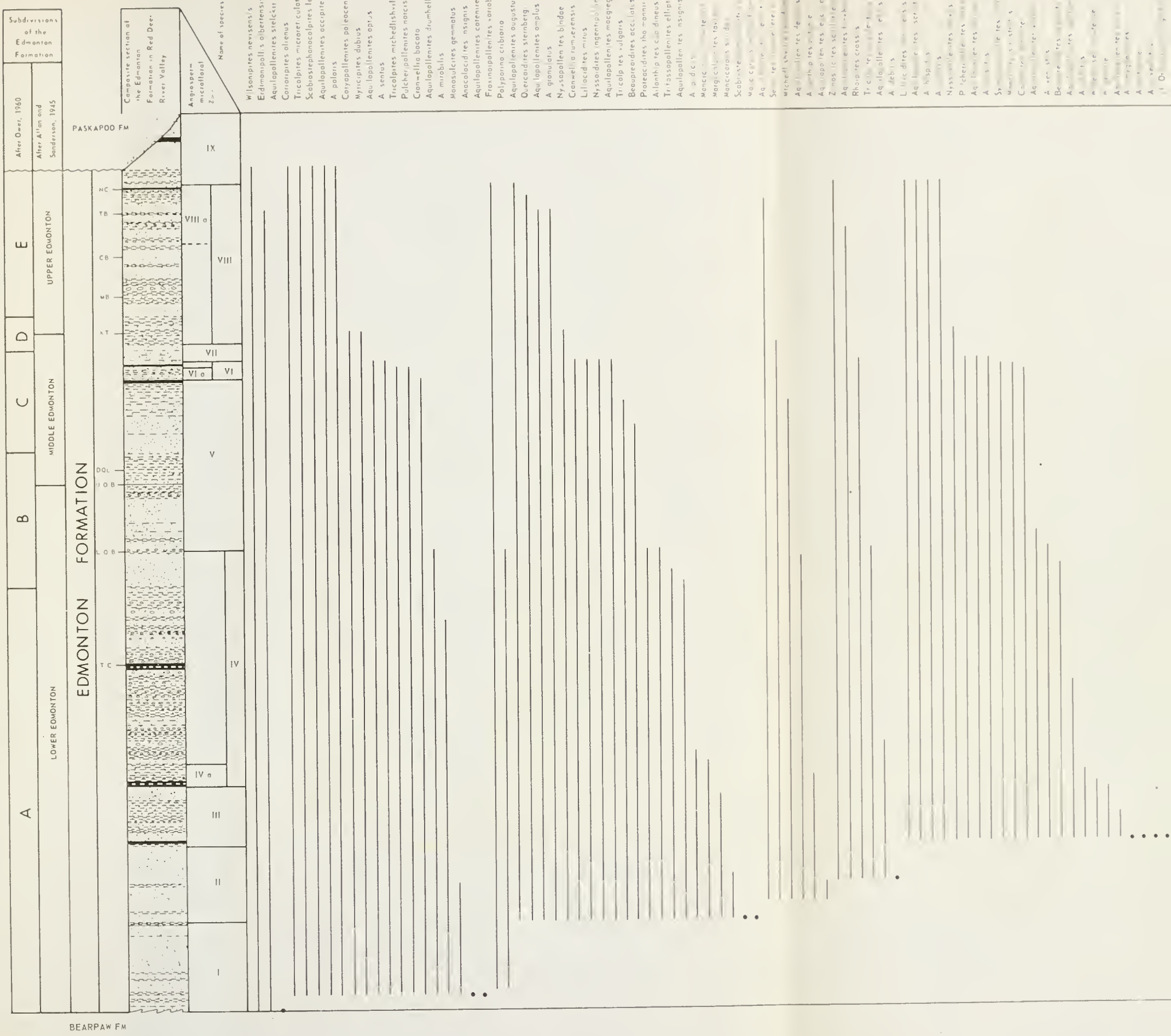
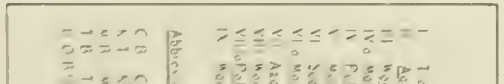


Fig 19 Vertical ranges of recovered angiosperm species within the Edmonton For



Aquilapollenites omicus
A. omygdaloides
A. antigonei
A. olveolatus
cf Orbiculapollis globosus

Nyssoidites edmontonensis
Aquilapollenites spinulosus
Mancicorpus senonicus
Aquilapollenites regolis
A. asper
Proteacidites aurotus
Beaupreoidites libitus
Loranthocites cotterollii
Aquilapollenites stellatus
A comosus
Ilexpollenites obscuricastatus
Grewipollenites conadensis
Monosulcites drumhellerensis
M. echinatus
Stelckia vero
S unico
S. xenoformis
Tubilifloridites aedicula
Erdtmania superba
Mancicorpus boreolis
Rhomnocidites minutapollenites
Aquilapollenites firmus
Pulcheripollenites krempii
Callistopollenites radiatostriatus
Rousea subtilis
Callistopollenites comis
Proteacidites tumidiporus var. ecollariatus
Liliacidites variegatus
Aquilapollenites petasus
Tetracolpites pulcher
Marcellopites talmonensis
Aquilapollenites vinosus
Talisiptes fischeri
Callistopollenites tumidoporus
Marcellopites basilicus
Aquilapollenites minutus
Alnipollenites finitimus
Faguspollenites gronulotus

LEGEND

I Transition Zone
II Aquilapollenites leucocephalus Zone
III Wodehouseo incurvata and W. gracile Zone
IV a Monicorpus boreolis Subzone
IV Pulcherrimpollenites krempii Zone
V Monicorpus voncampoi Zone
VI Scollardia trapaformis Zone
VI a Monicorpus gibbus Subzone
VII Azolla and Balmeisporites bearing interval
VIII Wodehouseo spinata Zone
VIIIa Polycolpites pacockii Subzone
IX Wodehouseo fimbriata Zone

Vertical scale = 60 ft

Abbreviations:

C. B Chamosaurus Bed, D Q L Dinosaur Quarry Level,
K. L Knoblitt Tuff, L O B Lower Oyster Bed
M B Mammal Bed, H C Nevis coalseam,
T B Triceratops Bed, T C Thompson coalseam,
U O B Upper Oyster Bed

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